



**THIOBENCARB USE IN COLUSA AND GLENN COUNTIES
FROM 1994-2000**

**Information submitted to the
Central Valley Regional Water Quality Control Board**

December 31,2000

**California Environmental Protection Agency
DEPARTMENT OF PESTICIDE REGULATION**

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State of California
California Environmental Protection Agency

Department of Pesticide Regulation
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Staff Report

Thiobencarb use in Colusa and Glenn Counties from 1994-2000

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With acknowledgement to
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for help with data investigation

Environmental Monitoring and Pest Management Branch

Introduction

The Department of Pesticide Regulation (DPR) received a memorandum (appendix 1) on February 24, 1998 from Gary M. Carlton, Executive Officer of the State of California Central Valley Regional Water Quality Control Board (CVWQCB). The memorandum described CVRWQCB's concern regarding increases of thiobencarb concentrations and performance goal exceedances in the Colusa Basin Drain (CBD5). The Board adopted Resolution No. 98-024 which addresses their concern. An additional element of the Resolution requests DPR to evaluate steps that can be used to reduce this trend of increased thiobencarb discharges and report the findings back to the CVRWQCB.

In response to the Board's request, DPR decided it necessary to analyze the relationship between thiobencarb detections at CBD5, and its application on rice fields in Glenn and Colusa counties during rice growing season. DPR staff used a geographic information systems (GIS) approach to spatially visualize use of thiobencarb, applied to rice fields during the months of pesticide application, typically from April through July from 1994-2000. Contributing factors to the off-site presence of thiobencarb include weather, water management, and application methods.

History

Weed competition with rice production has been a historical problem, especially with *Echinochloa crus-galli* (barnyard grass), *Echinochloa oryzoides* (early watergrass), and *Echinochloa phyllopogon* (late watergrass). In early rice culture management practices such as water seeding and deep water were the primary tool growers used to manage these weeds. Barnyard grass was successfully suppressed, when continuously submerged up to six inches. Late watergrass was still prevalent in spite of continuous flooding. Since the early days of rice farming, weed pressures have intensified due to increases in weed population and seed dispersal. In the late 1940's spread of weeds occurred due to farmers using rice seed contaminated with weed seed. Rice farmers fought weeds primarily by utilizing crop rotation, moving to new land never before farmed with rice, and flooding rice to suppress weed growth. In 1948 the herbicide 2,4-D was introduced for weed control, but rice soon began showing phytotoxic reaction to 2,4-D. Rice growers began using the herbicide MCP in the early 1950's, but largely cultural practices of flooding and crop rotation remained reliable for weed suppression. Growers began using Ordram[®] (molinate) and propanil herbicides in the 1960's.

Introduced in 1981, thiobencarb, a carbamate herbicide, is the active chemical ingredient of the rice herbicides Bolero[®] and Abolish[®]. Bolero[®] is a granular/flake herbicide which is applied to water post-flood to rice fields. Abolish[®] is an emulsifiable concentrate herbicide, applied pre-plant, pre-flood directly to the soil, or post-flood, post-emergence to drained fields. Both products are applied at an application rate up to four pounds active ingredient per acre, and have a narrow window of application due to phytotoxic injury that can occur to rice plants. That application window occurs after the rice plants have grown to the 1½ leaf stage, and before watergrass or barnyardgrass growth has progressed past the 1½ leaf stage. Aerial application methods are primarily used to apply

thiobencarb alone, or in combination with other herbicides to control annual grass weeds such as late and early watergrass and barnyardgrass (*Echinochloas*), smallflower umbrella sedge (*Cyperus difformis*), and sprangletop (*Leptochloa fascicularis*). In California, watergrass and barnyardgrass are the most serious weeds in rice culture and as few as three plants per square foot have demonstrated dramatic rice yield losses¹. Geographical occurrence and population density of sprangletop continues to increase yearly in rice growing counties of the Sacramento Valley. Sprangletop, and watergrass, can be successfully suppressed when water depths on the rice paddy are kept deep (8-15 inches) in the stage of early rice establishment, and for 21 days following. Organic rice farmers are successful at utilizing deep water, crop rotation, and other cultural strategies for sprangletop and watergrass suppression. Following initial flooding, rice fields grown organically are allowed to dry for approximately 35 days. This process allows control of broadleaf weeds and sedges without harm resulting to the rice seedlings. After the weeds have wilted, the fields are flooded with three to four inches of water. In conventional rice farming the grower is more likely to keep water depth at four to six inches, utilizing herbicides for weed suppression, during rice establishment, to avoid losing rice stands. This lower initial water depth favors weed establishment. Organic rice commands a higher return at the specialty market organic farmers serve, and that monetary return tends to make up for rice stand losses that conventional rice growers want to avoid.

Prior to 1992, Londax[®] (bensulfuron methyl) in combination with molinate, provided good control for virtually all broadleaf and grass weeds found in rice. In 1992, biotypes of smallflower umbrella sedge, ricefield bulrush (*Scripus mucronatus*), redstem (*Ammania coccinea*), and California arrowhead (*Sagittaria motevidensis*) with resistance to bensulfuron methyl had become widespread. Most rice growers then switched back to using Abolish[®] and Bolero[®], resulting in a dramatic rise in thiobencarb use.

Off-site movement of thiobencarb into agricultural drains and watersheds adjacent to rice growing areas occurs, during and following application. These waterways eventually flow into the Sacramento River. Several mechanisms are probably responsible for this off-site movement. The timing of some high herbicide concentrations in agricultural drains have coincided with the timing of aerial applications, and their presence cannot be attributed to early or normal water holding releases. In addition, late Spring storms sometime occur in April and May around the time thiobencarb is applied, prior and during rice seeding and establishment. Consequently, there are occasional early emergency releases of rice field water before water-holding requirements have elapsed and adequate degradation of thiobencarb has occurred. Ideal conditions for thiobencarb dissipation occurs when water is held on the rice fields following application for 30 days for Bolero[®], 19 days for Abolish[®], and when warm Spring temperatures are present encouraging photolysis, thiobencarb's main degradation pathway (figure 1). Thiobencarb and it's degradates (table 1) adhere to soil particles, and even when adequate holding requirements are met, detectable levels of thiobencarb can exist in rice field tailwater.

¹ *A Pest Mangement Evaluation for California Rice. 1998.* James E. Hill, L.D. Godfrey, A.J. Fischer, R.K. Webster, T.C. Cuneo, and S.R. Roberts. The University of California Cooperative Extension.

Figure 1. Photolysis pathways of thiobencarb in water

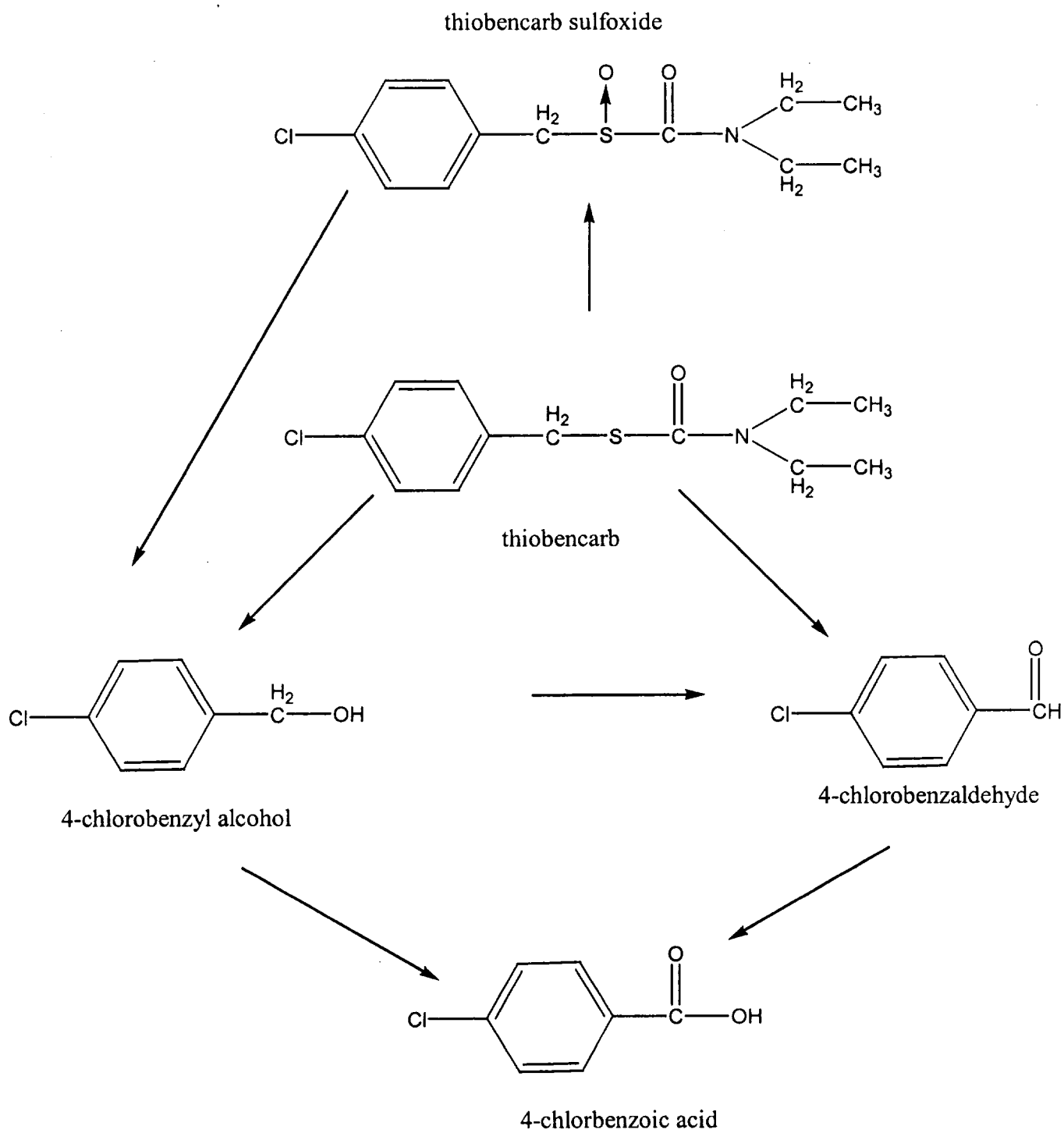
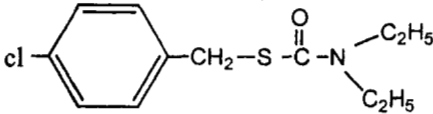
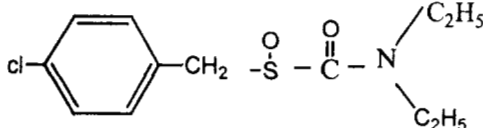
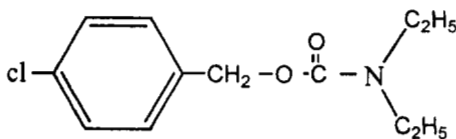
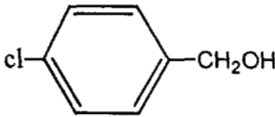
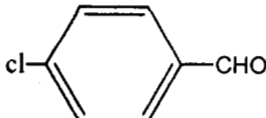
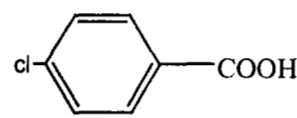


TABLE 1
CHEMICAL NAMES, DESIGNATIONS AND STRUCTURES
OF POSSIBLE THIOBENCARB METABOLITES

DESIGNATION	CHEMICAL NAME	STRUCTURE
THIOBENCARB	S-[(4-chlorophenyl)methyl]diethyl carbamothioate	
THIOBENCARB SULFOXIDE RE-42210	N,N-diethyl-(4-chlorobenzyl thiocarbamate S-oxide)	
BENCARB (RE-32239)	O-[(4-chlorophenyl)methyl]diethyl carbamate	
4-CB ALCOHOL CAS #:873-76-7	4-chlorobenzyl alcohol	
4-CB ALDEHYDE CAS #:104-88-1	4-chlorobenzaldehyde	
4-CB ACID CAS #:74-11-3	4-chlorobenzoic acid	

In the early 1980's, the California Department of Fish and Game (DFG) documented water and fish tissue analysis results showing molinate, another rice herbicide, was causing large fish kills in agricultural drains adjacent to rice growing areas in the Sacramento Valley threatening beneficial uses of these waters. High levels of thiobencarb were also found at the same time in agricultural drain water. Beginning in 1983, California's main agency regulating pesticides (now DPR, then a California Department of Food and Agriculture division), DFG, State Water Resources Board (SWRB), Central Valley Regional Water Quality Control Board (CVRWQCB), University of California (UC), County Agricultural Commissioners (CACs), pesticide registrants, and the rice industry worked together to develop plans to control pesticide discharges from rice fields. By the beginning of 1984, DFG and California Department of Health Services (DHS) developed criteria based on ecological and human health toxicological assessments. DFG recommended that thiobencarb concentrations in agricultural drains and the Sacramento River should not exceed 24 ppb in order to protect the aquatic environment. DHS developed a thiobencarb primary action level of 10 ppb in drinking water to protect human health in drinking water. A secondary action level of 1.0 ppb was established due to a taste threshold which results when thiobencarb and its breakdown products are present in drinking water. The primary action level was revised in 1988 based on further scientific review of toxicology, and a Maximum Contaminant Level (MCL) of 70 ppb was set by DHS.

Mitigation measures were implemented including:

- Mandatory post-application water holding time to allow for pesticide degradation prior to release into receiving waters.
- A restriction on total treated acreage (began in 1984) where only 100,000 acres could be treated with thiobencarb.
- Limiting applications to fields where approved water management techniques were utilized.

An initial dramatic reduction in concentrations in off-site waterways resulted from thiobencarb use restrictions imposed in the early 1980's, and thiobencarb concentrations decreased below DFG criteria and much less frequently exceeded DHS recommended levels. Water holding periods subsequently became the primary tool for reducing post-application off-site movement of rice pesticides. By 1988, a mandatory 30-day post-application holding period was required for thiobencarb, and the pesticide registrant had agreed to sales limitations that defined location and amount of acreage that could be treated with thiobencarb.

In 1990, the CVRWQCB added amendments to their water quality control plan establishing performance goal water quality standards for rice pesticides, including thiobencarb. CVRWQCB established a water quality performance goal of 1.5 parts per billion (ppb) for thiobencarb in all waters designated as freshwater habitat. This included the Colusa Basin Drain (CBD5), an agricultural drain located southwest of the town of Colusa near Highway 20, in Colusa County. Farming in this area was historically used as a means of reclaiming land and converting it to agriculture, that once was dominated by

tule, marsh, and cycles of natural flooding. Maps as early as 1920, denote many of the waterways in this area as agricultural conveyances such as canals, levies, and sloughs. Agricultural drainage contributes heavily to CBD5 flow most of the year. DPR has worked cooperatively with the Rice Industry Association in the past, and most recently with the California Rice Research Board to sample water annually at CBD5, generally collecting samples once or twice weekly, during late April through early July, and analyzing for rice pesticides.

The City of Sacramento also monitors water for molinate and thiobencarb at their drinking water intake on the Sacramento River (SRRAW). The City of Sacramento logs taste complaints on a yearly basis from people whose water source comes from SRRAW. The City receives an average of 2-3 taste complaints from water customers yearly. The complainants are mostly people who experienced high levels in drinking water (up to 13 ppb) that occurred in the early 1980's. Peak levels have declined measurably since that time (table 2). However, City of Sacramento water quality engineers state that recent taste complaints occur about the same time that thiobencarb is detected above the 0.1 ppb level at SRRAW. The current primary Maximum Contaminant Level (MCL) set by the DHS is 70 ppb for thiobencarb. The secondary thiobencarb MCL for off-taste complaints in drinking water is 1.0 ppb.

The (CAC's) enforce DPR's Rice Pesticide Program requirements by:

- informing growers, advisors, and operators of program provisions and insuring compliance utilizing inspections.
- issuing restricted material permits.
- approving or disapproving emergency release variances.
- encouraging responsible cultural practices.
- educating growers to minimize pesticide off-target movement.
- and reporting rice pesticide data to DPR.

Thiobencarb is a restricted material and cannot be applied by rice growers unless a Notice-of-Application (NOA) is filed with the CAC 24 hours prior to the application. This enables CAC staff to observe the mixing, loading, and applications, and to track post-application water holding times. Growers that violate any applicable regulations regarding these activities can be cited, and agriculture civil penalties can result in fines.

Aquatic Toxicity of Thiobencarb

Water quality criteria for thiobencarb were developed based on fifty studies reviewed by the California Department of Fish and Game. DFG determined a final acute value (FAV) of 247 ug/L and a Final Chronic Value (FCV) of 16 ug/L. These data were based in part on *Neomysis mercedis*, the most sensitive known species and a native of the Sacramento River. The chronic water quality criterion was subsequently reduced to 6.2 ug/L, 61% lower than the former calculated FCV, due to partial life-cycle tests performed prior to standardized test procedures developed for mysids. Molinate and thiobencarb frequently co-occur in receiving waters due to similar use patterns and off-site movement in rice. The chemicals are assumed to have simple additive toxicity. Therefore, the recommended

Table 2. City of Sacramento monitoring results for thiobencarb in parts per billion (ppb) from the City of Sacramento water treatment facility SRRW from 1994-2000.

Date	Year of Monitoring						
	1994	1995	1996	1997	1998	1999	2000
8-May							<0.10
10-May	<0.10						
15-May				<0.10			
16-May			<0.10				0.19
17-May		<0.10				<0.10	
19-May				<0.10			
20-May					<0.10		
21-May				<0.10			
22-May		<0.10					0.28
23-May	<0.10		<0.10				
24-May						0.25	
25-May		<0.10			<0.10		
26-May	<0.10			<0.10			0.15
27-May			<0.10			<0.10	
28-May							0.18
29-May		<0.10					
30-May	<0.10		<0.10	<0.10			
31-May						0.30	
1-Jun		<0.10			0.14		
2-Jun	<0.10			<0.10			
4-Jun			<0.10		<0.10	0.34	
5-Jun		<0.10	<0.10	<0.10			0.18
6-Jun	<0.10			<0.10			
7-Jun			<0.10				
8-Jun						0.33	
9-Jun	<0.10	<0.10		<0.10	<0.10		
11-Jun			<0.10	<0.10			
12-Jun		<0.10					0.22
13-Jun	<0.10						
14-Jun			<0.10			0.29	
15-Jun		<0.10			<0.10		<0.10
16-Jun	<0.10						
17-Jun			<0.10				
19-Jun		<0.10					
20-Jun			<0.10				
21-Jun						<0.10	
22-Jun		<0.10					
26-Jun		<0.10					
29-Jun					<0.10		
30-Jun		<0.10					

Limit of detection is 0.10 ppb.

criterion of 3.1 ug/L for thiobencarb was established. This level provides a two-fold margin of safety as it is also based on maximum concentrations that are considered twice the average value (Harrington, 1990). At CBD5 occasional concentrations would be considered injurious to *Neomysis mercedis*, however this mysid shrimp is not native in the agricultural drains in rice growing areas. Sacramento River at Village Marina (SR1) is another monitoring site included in the yearly monitoring of the Rice Pesticides Program. At this site all samples were non-detect (ND) for thiobencarb from 1994-2000. Therefore, DPR has found no evidence that supports toxic concentrations of thiobencarb, hazardous to the mysids at this Sacramento River monitoring site occurred. DFG at one time proposed further investigations be carried out to see if other sensitive species were harmed at lower concentrations, but these data have not been developed.

Both frequency of thiobencarb detection and median thiobencarb concentrations at CBD5 have increased markedly from 1994-2000 (figure 2): out of 126 samples collected by DPR and analyzed for thiobencarb during that period, 70 samples have exceeded the performance goal. Of those, nine were above 10.0 ppb. The two highest concentrations were 37.4 ppb in 1994 and 16.2 ppb in 1996. Of the remaining samples, 15 were within the range from 5.0-10.0 ppb, 44 samples were below 5.0 ppb but above the 1.5 ppb performance goal, 25 samples were 1.5 ppb or below, and 33 samples were non-detected (ND) for thiobencarb (table 3). There was a single thiobencarb detection of .50 ppb in water analyzed at the Sacramento River (SR1) monitoring site on June 8, 1999. All other samples analyzed from 1994-2000 were non-detected for thiobencarb at SR1.

Figure 2. Annual exceedances of thiobencarb water quality performance goals and median concentrations at CBD5 (May - July samplings)

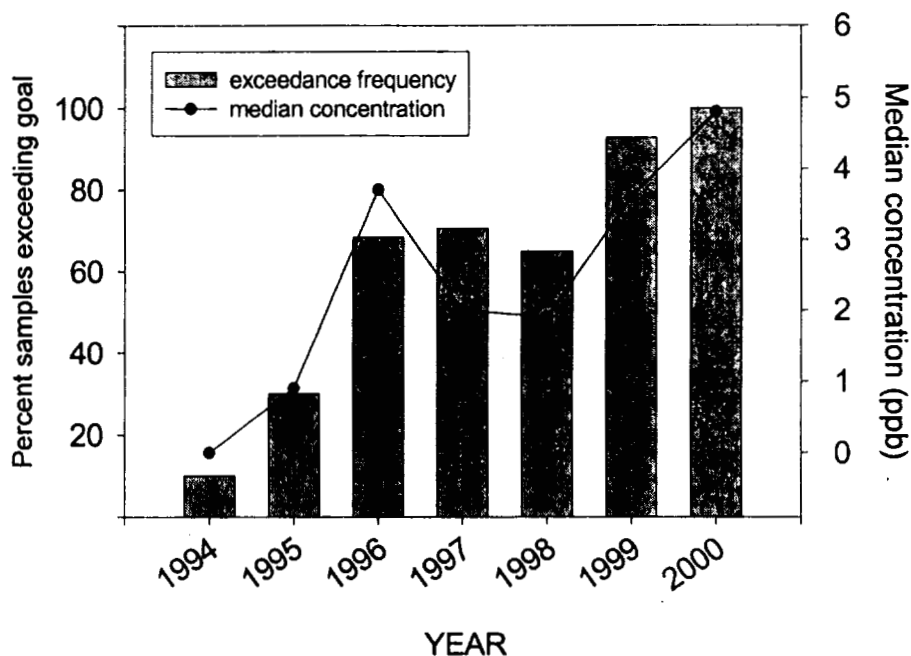


Table 3. Thiobencarb concentrations at Colusa Basin Drain (CBD5) from 1994-2000.

Bolded numbers indicate performance goal (1.5 ppb) violations.

1994		1995		1996		1997	
Date	Concentration (ppb)	Date	Concentration (ppb)	Date	Concentration (ppb)	Date	Concentration (ppb)
5/3	ND	4/14	ND	4/1	ND	3/31	ND
5/5	ND	5/16	NS	4/23	ND	4/22	ND
5/9	ND	5/18	1.2	4/25	ND	4/24	ND
5/12	ND	5/23	NS	4/30	ND	4/29	0.7
5/16	37.4	5/25	0.87	5/2	ND	5/1	ND
5/19	0.768	5/30	NS	5/7	ND	5/6	1.9
5/22	1.04	6/1	2.68	5/9	ND	5/8	1.4
5/26	0.992	6/6	NS	5/14	1.5	5/13	3.6
5/30	0.66	6/8	3.7	5/16	2.9	5/15	4.1
6/2	4.0	6/13	NS	5/18	4.65	5/20	12.3
6/6	0.5	6/15	0.872	5/21	5.0	5/22	6.0
6/9	ND	6/20	NS	5/23	6.8	5/27	4.4
6/13	ND	6/22	0.758	5/26	4.54	5/29	3.3
6/16	ND	6/27	NS	5/28	7.7	6/3	4.2
6/20	ND	6/29	2.17	5/30	1.10	6/5	2.6
6/23	ND	7/3	NS	6/4	3.00	6/10	2.0
6/27	0.508	7/6	0.682	6/6	5.9	6/12	2.0
6/30	0.63	7/11	NS	6/11	16.2	6/17	1.3
7/4	ND	7/13	0.5	6/13	3.7	6/19	1.5
7/7	ND	7/18	NS	6/18	3.9	6/24	1.3
		7/20	ND	6/20	4.0	6/26	1.3
				6/25	1.0		
				6/27	1.3		

1998		1999		2000	
Date	Concentration (ppb)	Date	Concentration (ppb)	Date	Concentration (ppb)
3/31	ND	4/13	ND	4/10	ND
5/5	ND	4/27	NS	4/25	NS
5/7	ND	4/29	NS	4/27	NS
5/12	ND	5/4	NS	5/2	NS
5/14	ND	5/6	NS	5/4	NS
5/19	ND	5/11	0.7	5/9	4.9
5/21	ND	5/13	1.6	5/11	4.6
5/26	1.2	5/18	4.2	5/16	6.7
5/28	1.8	5/20	3.7	5/18	10.7
6/2	9.1	5/25	10.0	5/23	6.2
6/4	9.7	5/27	10.9	5/25	10.4
6/9	6.4	6/1	6.3	5/30	9.2
6/11	6.6	6/3	4.8	6/1	6.1
6/16	11.0	6/8	10.9	6/6	3.7
6/18	8.4	6/10	3.5	6/8	3.5
6/23	2.8	6/15	2.0	6/13	2.3
6/25	2.0	6/17	2.1	6/15	3.1
6/30	2.2	6/22	2.3	6/20	2.1
7/2	1.8	6/24	2.1	6/22	1.7
7/7	1.9				
7/9	1.9				

Detection Limit=0.5 ppb

ND-Not Detected

NS-Not Sampled

Summary of Rice Pesticide Activities 1994-2000

1994

Sumovement of rice pesticides. CAC's enforced the requirement that growers who repeatedly violate water holding requirements, resulting in early emergency releases, make improvements to their water management practices by conditioning the use permits. These improvements included installation of pumps for rice field water recirculation or f Additional management measures were developed in 1994 allowing adjacent land to contain run off water. DPR required that rice growers secure the weir boxes in their rice fields with plastic and fill around them with soil to a depth higher than the water level in order to prevent uncontrolled seepage around and through the boxes. Stricter application requirements were implemented to better control pesticide drift (appendix 2).

In 1994, 123,000 acres of rice were planted in Colusa County and 81,000 acres in Glenn County. There were 83 applications of Abolish® applied to 6,446 acres and 205 applications of Bolero® applied to 15,852 acres in Colusa County. In Glenn County 82 applications of Abolish® were applied to 5,021 acres and 50 applications of Bolero® to 3,777 acres (table 4). A sales limitation that restricted 1993 use of thiobencarb to 4.4 million pounds or 110,000 acres was eliminated in 1994. Justification for eliminating the sales restrictions included longer water holding times that were in place; interest in use of Abolish 8EC® with the pin-point flood application method; improvements in the construction and maintenance of soil berms around drain weirs; and a forecast that sales of Bolero® and Abolish® would not increase in 1994.

Weather conditions in 1994 were considered normal, with only one unusual cool period with minimal rainfall during late April through early May. Rice growers utilized water conservation measures in late May and June, resulting in low water flows in CBD5. This resulted in low dilution of any pesticides that were present during these months. There were nine detections of thiobencarb and two performance goal violations between June 16 and June 30 in 1994 (figure 3). The peak concentration of thiobencarb detected at CBD5 was 37.4 ppb on May 16 (table 3). DPR staff investigated applications and concluded that aerial drift was the most likely cause of this high concentration, resulting from a thiobencarb application to 107 acres that was made 1.5 miles north of the monitoring site at CBD5 bordering the drain. The only other violation of the performance goal occurred on June 2 when thiobencarb was found at 4.0 ppb.

Three emergency release variances, totaling 172 acres were granted in 1994. Applications of thiobencarb had not been made to these fields, according to pesticide use reports submitted to DPR. Legal releases commenced in mid-May and a period of increased flows at CBD5 occurred beginning on May 8 and ending on May 12. There were only 215 thiobencarb treated acres that could have been released around this time. Additionally, this acreage would have endured the full 30-day holding time. DPR staff concurred that drift and the result of legal releases were the most likely causes of the

Table 4. Total acres treated and pounds active ingredient (AI) applied of Abolish® and Bolero® (Thiobencarb) in Glenn and Colusa counties 1994-2000.

	Year	Total Acres Planted	Total Acres Harvested	<u>Number of Applications</u>		<u>Abolish®</u>		<u>Bolero®</u>		<u>Combined Totals</u>	
				Abolish®	Bolero®	Acres Treated	LBS AI	Acres Treated	LBS AI	Total Acres	Total Lbs AI
Colusa County	1994	123,000	122,700	83	205	6,446	25,559	15,852	87,406	22,298	112,965
	1995	122,000	121,400	149	376	13,706	60,937	27,962	112,158	41,668	173,095
	1996	136,000	135,700	154	563	13,051	54,700	45,024	188,420	58,075	242,120
	1997	137,000	136,400	201	858	16,178	68,746	62,254	242,907	78,432	311,653
	1998	121,000	120,000	90	587	7,628	29,595	46,142	184,915	53,770	214,510
	1999	135,000	134,000	64	555	3,758	15,384	41,982	163,928	45,740	179,312
	2000	157,233	*	49*	1,137*	4,207*	**	86,655*	**	90,862*	**
Glenn County	1994	81,000	80,700	82	50	5,021	19,583	3,777	14,435	8,798	34,018
	1995	79,000	78,700	59	51	3,977	15,716	3,378	13,320	7,355	29,036
	1996	87,000	86,700	31	139	1,406	6,808	11,149	40,066	12,555	46,874
	1997	89,000	88,600	55	245	2,328	9,189	17,509	67,044	19,837	76,233
	1998	83,000	83,000	61	364	3,255	12,289	25,639	101,671	28,894	113,960
	1999	88,000	87,500	32	328	1,866	6,921	23,374	89,809	25,240	96,730
	2000	87,383	*	32	361	1,720*	**	28,801*	**	30,521*	**

* Preliminary data subject to revision reported by County Agricultural Commissioners.

**Data of active ingredient applied currently not available.

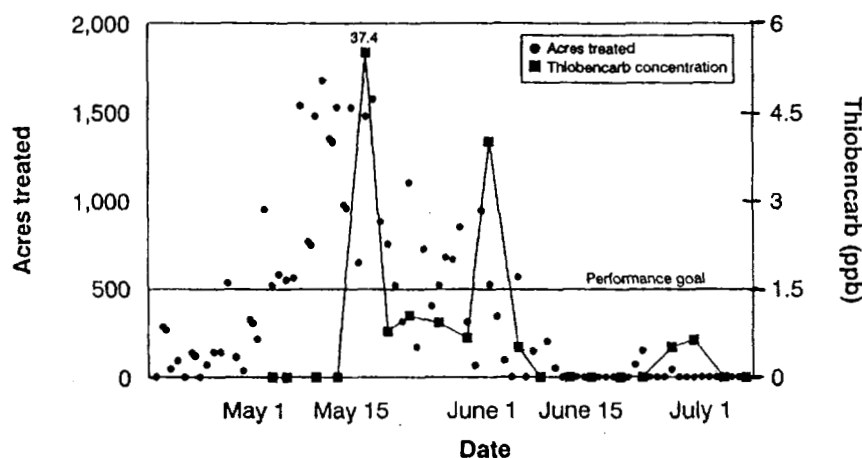
Remaining data is from finalized, error checked, DPR Pesticide Use Reporting Database.

Planted and harvested acreage data is from California Department of Food and Agriculture agriculture statistics.

June 2 detection. CAC's inspected 1600 rice fields and cited nine growers for holding time violations. Four of these violations were due to water unintentionally leaking around rice weir boxes.

There were nine detections of thiobencarb and two performance goal violation between June 16 and June 30 in 1994. There was no thiobencarb detected at the City of Sacramento water treatment facility (SRRAW) in 1994. The limit of detection (LOD) was 0.10 ppb at SRRAW.

Figure 3: Acres treated with thiobencarb in Colusa and Glenn Counties and concentrations detected at CBD5 in 1994.



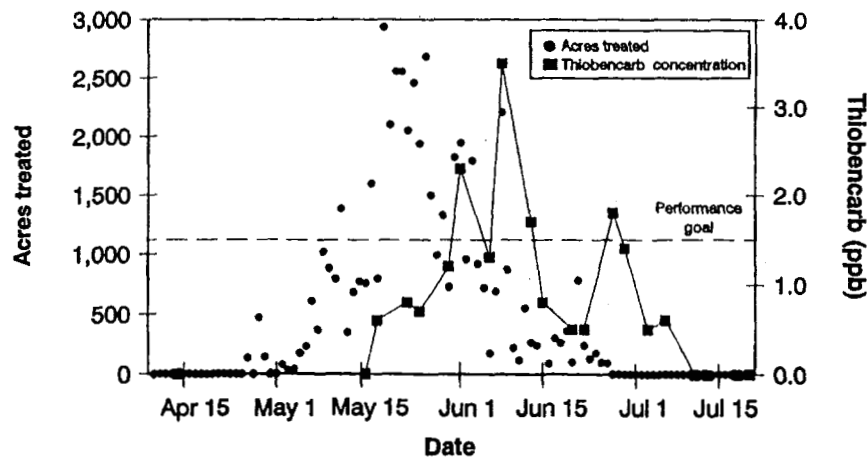
1995

In 1995 water management requirements were further revised to include a 19-day holding period be allowed for Abolish® and generally refined holding times for the liquid formulation of thiobencarb due to it's method of application. The holding time remained 30 days in all rice fields treated with thiobencarb except where the grower's tailwater recovery system is part of a regional recirculating water system, or where negligible amounts of field water are discharged into surface waterways (appendix 3a). Emergency releases could be granted by CACs when weather events caused flooding, or rice crops were threatened with loss and long holding periods could be shown as the cause. In 1995 122,000 acres of rice was planted in Colusa County and 79,000 was planted in Glenn County. In Colusa County 149 applications of Abolish® was applied to 13,706 acres and 376 applications of Bolero® were made to 27,962 acres. In Glenn County 59 applications of Abolish® were made to 3,977 acres and 51 applications of Bolero® were made to 3,378 acres (table 4).

flooding, requested to release water from RD1000, normally a closed district. DPR staff consulted with Central Valley Regional Water Quality Control Board (CVRWQCB) staff and it was agreed to allow the district to pump water out of the system on June 17 and 18. DPR collected water samples on June 17, 18, and 19 to investigate pesticide concentrations present in this released water. Thiobencarb was present only on June 18 at 0.6 ppb. Though overall the flows were increased in the agricultural drains early in the season, opposite conditions existed in the late season and due to water conservation practices in Glenn and Colusa counties, discharges did not occur through the control gates into the Sacramento River at Knight's Landing from May through June. DPR staff concluded that drift and seepage accounted for concentration peaks during and directly after application in 1995. Legal releases and emergency releases occurred two to four weeks following application. Eleven emergency releases were granted totaling 772 acres. None of these releases were from acreage that was treated with thiobencarb according to pesticide use reports.

CACs and DPR's Pesticide Enforcement Branch inspected 3,163 rice fields for water holding restriction compliance, resulting in 17 violations. Three of these violations led to agriculture civil penalty action. There were nine detections of thiobencarb and three performance goal violations occurring from May 18 through July 13 in 1995 (figure 4). Thiobencarb concentrations in Colusa Basin Drain peaked at 3.7 ppb on June 8 (table 3). There was no thiobencarb detected (LOD= 0.10 ppb) at the City of Sacramento water treatment facility (SRRAW) in 1995.

Figure 4: Acres treated with thiobencarb in Colusa and Glenn Counties and concentrations detected at CBD5 in 1995.



1996

In 1996 136,000 acres of rice was planted in Colusa County, an increase of 14,000 from 1995. In Glenn County 87,000 acres of rice was planted, an increase of 8,000 acres from 1995. There were 154 applications of Abolish® made to 13,051 acres and 563 applications of Bolero® made to 45,024 acres in Colusa County. Glenn County reported 31

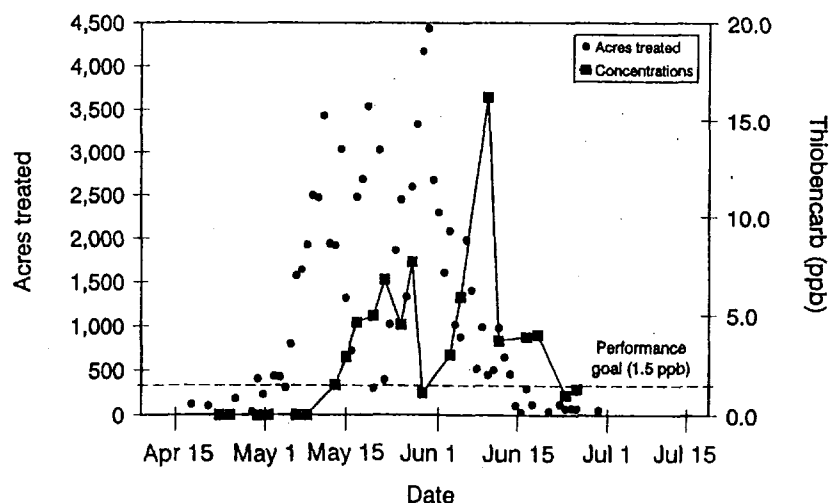
applications of Abolish® made to 1,406 acres and 139 applications of Bolero® made to 11,149 acres (table 4).

Heavy mid-May rains and strong winds resulted in 89 emergency releases from 7,197 acres and a release from 540 acres in RD1001 normally a closed Reclamation District. Emergency releases were only allowed from fields, where winds and water threatened destruction of crops and levees; failure to allow releases may have resulted in uncontrolled releases of a greater amount of water containing pesticides. There were five emergency releases from 220 acres that contained water treated with thiobencarb in Colusa County between May 17 and May 29 in 1996. These releases were attributed to uncontrollable flooding conditions threatening to breach levees and roads. Emergency released acreage in Glenn County had not been treated with thiobencarb. The unseasonably cool, wet weather was not favorable for dissipation of thiobencarb and favored weed growth pressure for the remainder of the growing season.

In 1996, CACs and DPR Enforcement Branch staff inspected 2,886 rice fields for water holding restriction compliance resulting in 21 growers cited for violations. There were 216 inspections of mixing and loading resulting in two non-compliance violations and 317 inspections of pesticide application with 23 non-compliances. Ten of these violations resulted in agriculture civil penalty action.

There were 16 detections of thiobencarb at CBD5 and thirteen detections that met or exceeded the performance goal (figure 5). The peak concentration was 16.2 ppb on June 11 (table 3). Thiobencarb was not detected (LOD=0.10 ppb) at the City of Sacramento drinking water intake (SRRAW) in 1996.

Figure 5: Acres treated with thiobencarb in Colusa and Glenn counties and concentrations detected at CBD5 in 1996.



1997

There were 137,000 acres of rice planted in Colusa County and 89,000 acres planted in Glenn County in 1997. In Colusa County 201 applications of Abolish® were made to 16,178 acres and 858 applications of Bolero® were made to 62,254 acres. In Glenn

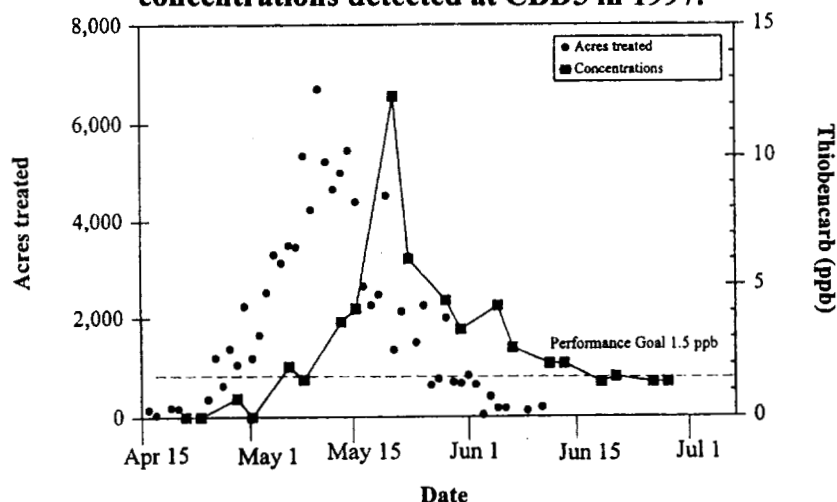
County 55 applications of Abolish® were made to 2,328 acres and 245 applications were made to 17,509 acres (table 4).

Weather conditions were considered normal in 1997 and favored early planting and good conditions for rice production. Two emergency releases were granted in 1997 but were not fields that had been treated with thiobencarb.

In 1997, CACs inspected 3,101 rice fields for water holding restriction compliance. There were four violations where growers were cited. There were 185 inspections of mixing and loading resulting in one violation, and 314 inspections of application resulting in five violations. Five of the total violations resulted in agriculture civil penalty actions.

There were 17 detections of thiobencarb resulting in 14 performance goal violations occurring from April 29 through June 26 (figure 6). The peak concentration of thiobencarb occurred on May 20 at 12.3 ppb (table 3). There were no detections (LOD= 0.10 ppb) at SRRAW in 1997.

Figure 6: Acres treated with thiobencarb in Colusa and Glenn counties and concentrations detected at CBD5 in 1997.



1998

There were 90 applications of Abolish® made to 7,628 acres and 587 applications of Bolero® made to 46,142 acres in Colusa County. In Glenn County 61 applications of Abolish® were made to 3,255 acres and 364 applications were made to 25,639 acres (table 4).

In 1998 further revisions were made to water management requirements allowing emergency releases where salinity in water held on fields could be documented at levels harmful to the rice crop (appendix 3b).

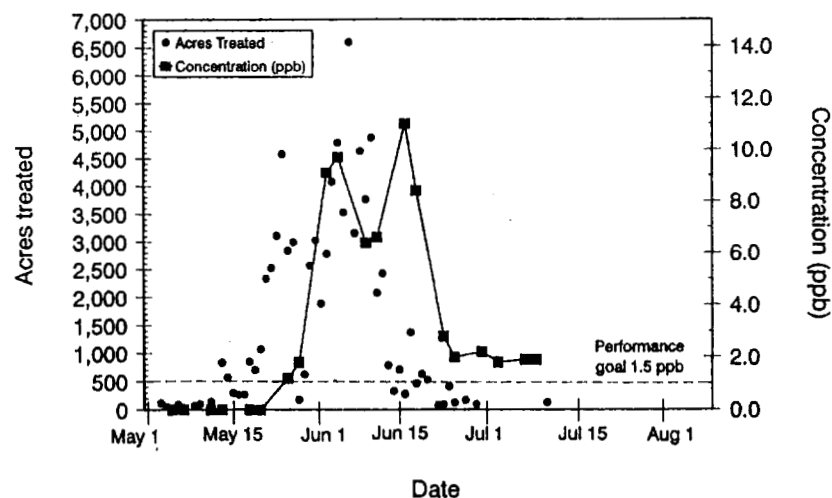
Extreme rain and cool temperatures predominated in March through May. The Moulton Weir rain gauge station near the town of Colusa measured seven inches of precipitation from rainstorms that occurred March 1 through June 1. Due to the inability to prepare

fields, growers were a month late in planting fields. There were 129 emergency releases in Colusa and Glenn counties combined. In Colusa County 25 emergency releases were granted to 3,312 acres that had been treated with thiobencarb. In Glenn County 17 emergency releases occurred from 2,057 thiobencarb treated acres. Uncontrolled releases also occurred due to levee failure from flooding. All of the emergency releases granted were weather related except one granted due to salinity.

DPR and the CACs of rice growing counties agreed on a Prioritization Plan and a Negotiated Workplan in 1998. Part of the plan includes a negotiated number of water hold inspections and restricted rice pesticides were ranked as high priority due to their special monitoring and study status. DPR partially reimburses the cost the counties bear based on the numbers of inspections conducted. In 1998, 3,291 rice fields were inspected for water holding restriction compliance, 262 inspections for pesticide mixing and loading, and 392 inspections of pesticide applications. There were eight violations that warranted agriculture civil penalty actions.

There were fourteen detections of thiobencarb in 1998 and thirteen concentrations which exceeded the performance goal (figure 7). The highest concentration of thiobencarb was 11.0 ppb on June 16 (table 3). There was one detection of thiobencarb at SRRAW of 0.14 ppb on June 1.

Figure 7: Acres treated with thiobencarb in Colusa and Glenn counties and concentrations detected at CBD5 in 1998.



1999

Rice acreage increased from 478,000 acres harvested in 1998 to 548,000 acres harvested in 1999 in rice growing counties of the Sacramento Valley combined. In Colusa County 135,000 acres were planted. There were 64 applications of 15,584 pounds active ingredient Abolish® made to 3,758 acres, and 555 applications of 163,928 pounds active ingredient of Bolero® made to 41,982 acres.

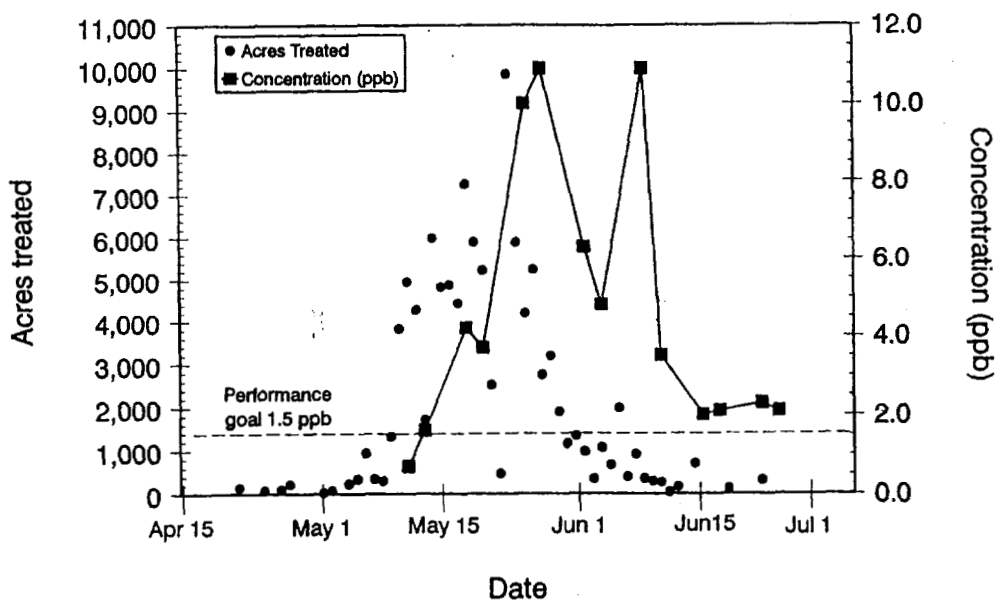
In Glenn County 88,000 acres of rice were planted. There were 32 applications of 6,921 pounds active ingredient Abolish® applied to 1,866 acres, and 328 applications of 89,809 pounds active ingredient Bolero® applied to 23,374 acres (table 4).

Weather conditions in 1999 were unseasonably wet and cool, conditions which do not favor thiobencarb dissipation. Weed pressures were high and rice stands were slow to mature which suppressed the ability of rice plants to out compete weed growth.

There were four emergency releases granted in 1999. Three of these releases were due to salinity in Colusa County and acreage involved had been treated with Bolero®. CAC staff made 2,793 inspections of fields to check for water-holding compliance. There were 507 pesticide application inspections and 263 mix/load inspections made. A total of 37 non-compliance and 15 agricultural civil penalties were issued.

The peak thiobencarb concentration in 1999 was 10.9 ppb on May 27 and on June 8 at CBD5 (figure 8). The performance goal for thiobencarb was exceeded 13 times on sampling dates from May 13 through June 24 (table 3) at CBD5. There were five detections of thiobencarb at the City of Sacramento drinking water intake. For the time period observed, thiobencarb concentrations in the Sacramento River in 1999 did not meet or exceed the human health maximum contaminant level for drinking water of 70 ppb or the secondary action level of 1.0 ppb set by the State of California Department of Health Services.

Figure 8: Acres treated with thiobencarb in Colusa and Glenn counties and concentrations detected at CBD5 in 1999.



2000

There were approximately 575,000 acres of rice planted in the Sacramento Valley in 2000. Of that total Colusa County had 157,233 acres and Glenn County had 87,383 acres

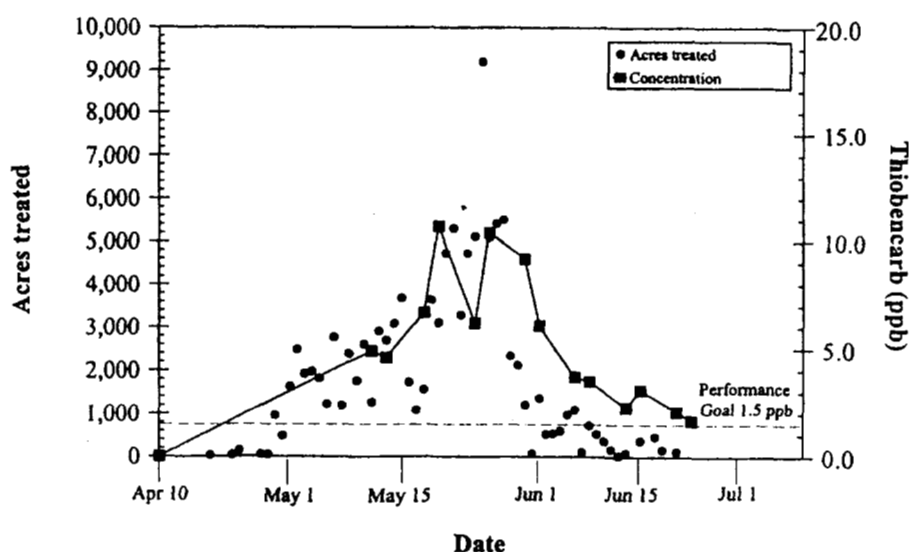
planted in rice. Colusa County reported 49 applications of Abolish made to 4,207 acres and 1,137 applications of Bolero® made to 86,655 acres (table 4). The most current data presented here are preliminary figures reported by the counties and are subject to change. Final data that is included in DPR's Pesticide Use Reporting Database are not available until the data undergoes quality control checks. Finalized data will be available in 2001. Total pounds active ingredient of Abolish® and Bolero® were not calculated on this preliminary data but will be available in 2001.

There were five emergency releases granted in Colusa County in 2000. Two of these releases occurred on May 19 from 158 acres treated with Bolero® and were due to rain causing flooded conditions. The remaining two releases, from 184 acres treated with Bolero®, occurred on June 14 and were due to salinity.

CACs inspected 2,634 rice fields for compliance with water-holding compliance. Nine Non-compliances occurred and five resulted in Agriculture Civil Penalties (ACP) being issued. There were 301 mix/load inspections of applications resulting in 24 non-compliances and on ACP was issued. There were 400 inspections of applications resulting in 17 non-compliances and eight ACPs were issued.

Thiobencarb was detected beginning on May 30 and was detected 13 times and concentrations exceeded the performance goal 10 times. The highest concentration in 2000 was on May 30 at 9.2 ppb (figure 9). Thiobencarb was detected six times at SRRAW in Sacramento. The highest concentration occurred on May 22 at .28 ppb. Concentrations were all above 0.1 ppb that could result in taste complaints even though the DHS taste threshold is set at 1.0 ppb.

Figure 9: Acres treated with thiobencarb in Colusa and Glenn counties and concentrations detected at CBD5 in 2000.



Seepage

DPR collected water samples during the 2000 rice pesticide monitoring period adjacent to rice fields, at one site each in Colusa and Glenn counties where seepage has been identified, to monitor for molinate and thiobencarb contained in seepage water. Seepage occurs when rice levees are improperly constructed or managed, allowing water being held on a rice paddy to move through the levee to surrounding ditches. This water can contain pesticides which have not endured the required holding time to degrade and can enter agricultural drains. Seepage may also occur where soils are sandy. DPR currently works with CACs, and encourages growers to follow management practices for levee construction that if followed, deter seepage from occurring. Information about seepage is provided at the time of permit issuance informing rice growers of the problem and recommending practices that they should follow. DPR continues to hope this voluntary approach will be successful in reducing seepage. Seepage water collected in the 1999 survey showed that both molinate and thiobencarb were present in adjacent ditches to treated rice fields (appendix 4).

Summary of Thiobencarb Use 1994-2000

In Colusa and Glenn counties total acreage treated with thiobencarb increased significantly from 1994-2000 (figure 10). The overall increase in use, in conventional rice growing, can largely be attributed to thiobencarb's reliability, effectiveness, relative longevity of use prior to weed resistance problems arising, and lack of other effective herbicides. Thiobencarb resistant watergrass has been discovered and UC researchers are currently identifying affected areas. Following initial introduction in rice weed management, lower use rates were effective and commonly used by growers. Today PUR data demonstrates that growers tend to apply at higher use rates with more applications. This suggests that effective control may not be occurring at the lower rates of use due to weed resistance. Geographical use of thiobencarb in Glenn and Colusa counties are shown in figures 11, 12, and 13.

**Figure 10. Total acres treated with thiobencarb in Glenn and Colusa counties
From 1994-2000.**

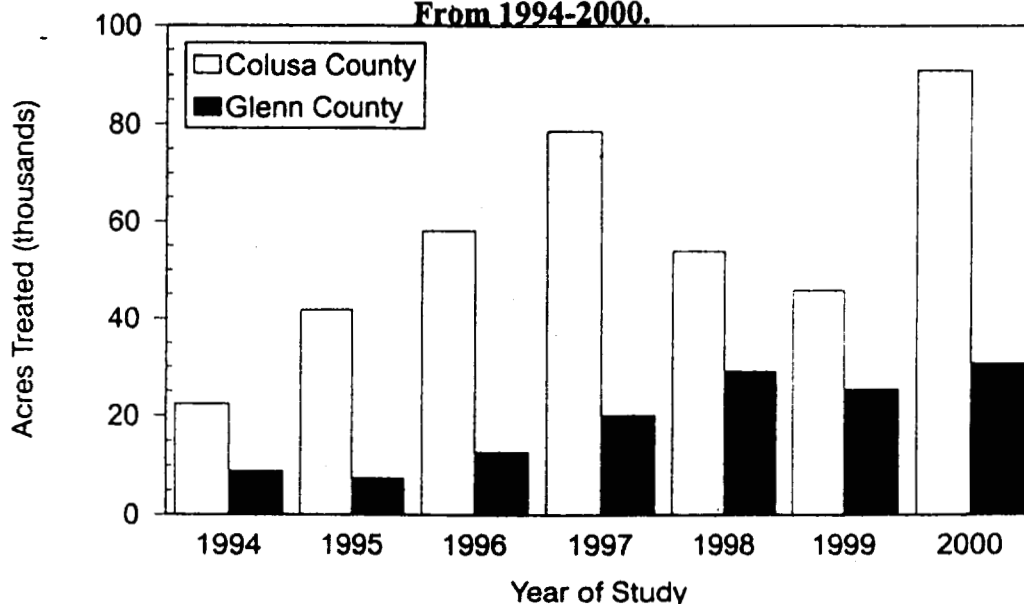


Figure 11. Thiobencarb use in Glenn and Colusa counties from 1994-1996 based on one-square mile sections.

(Based on data from Department of Pesticide Regulation's Pesticide Use Reporting Database.)

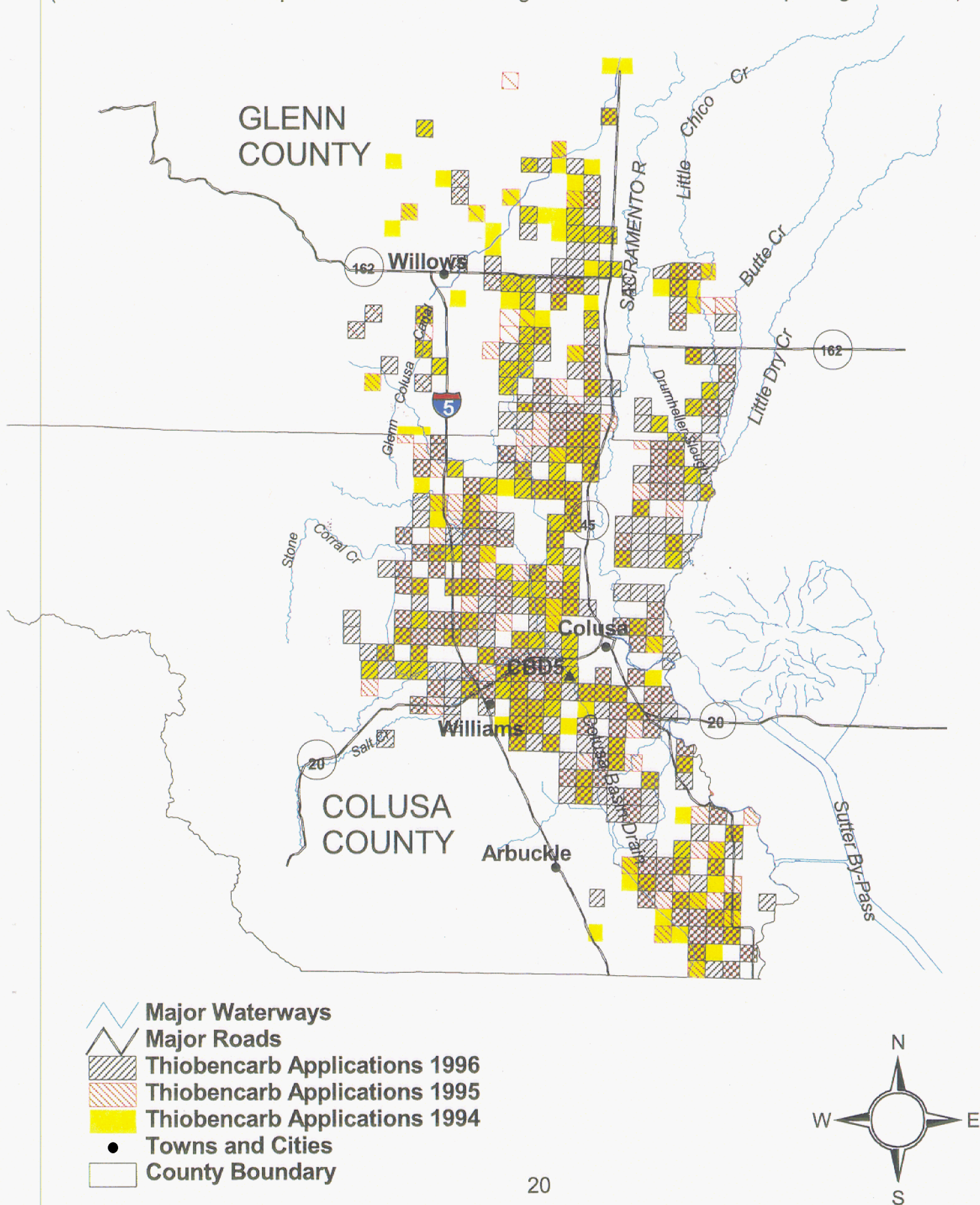


Figure 12. Thiobencarb use in Glenn and Colusa counties from 1997-1999 based on one-square mile sections.

(Based on data from Department of Pesticide Regulation's Pesticide Use Reporting Database.)

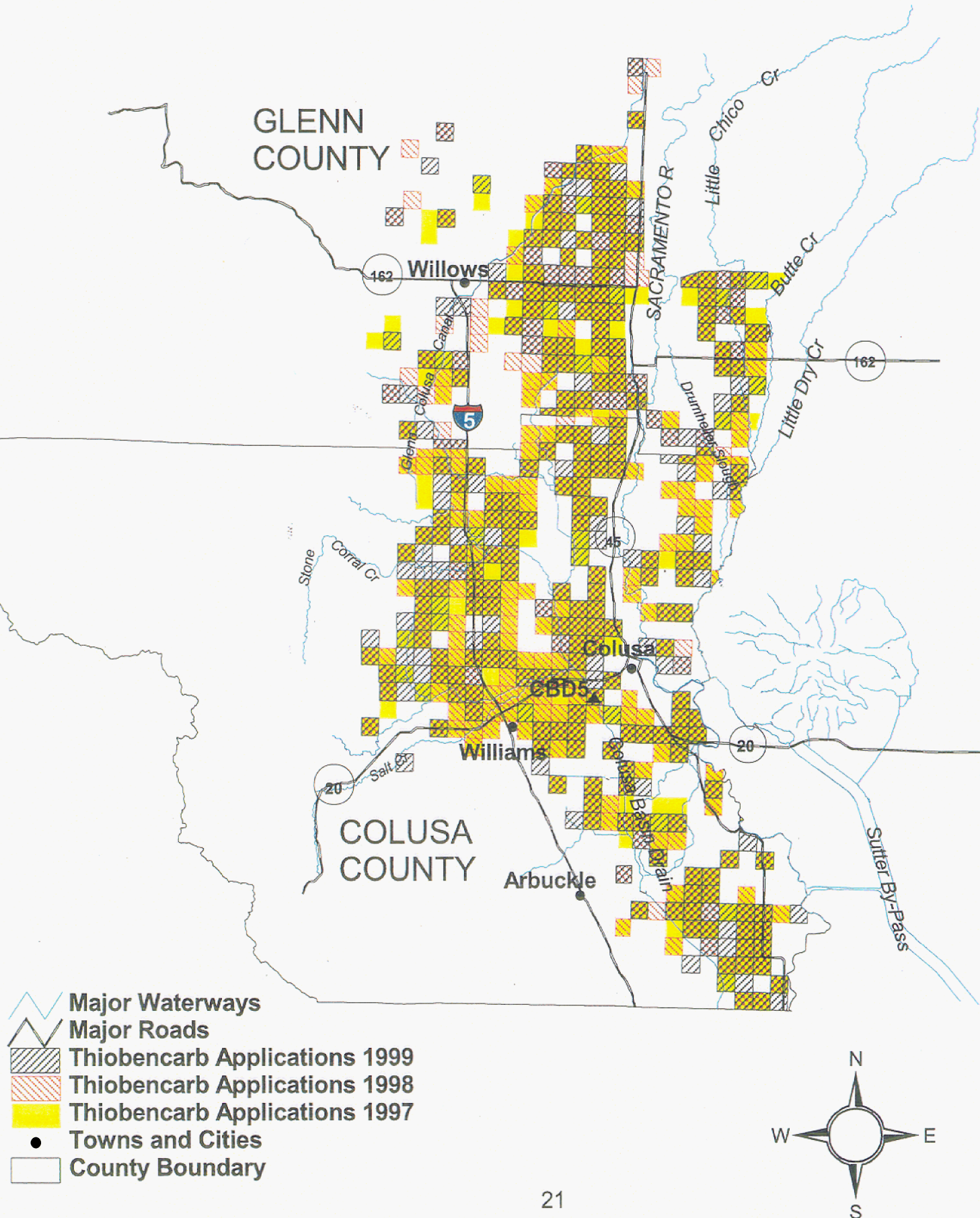
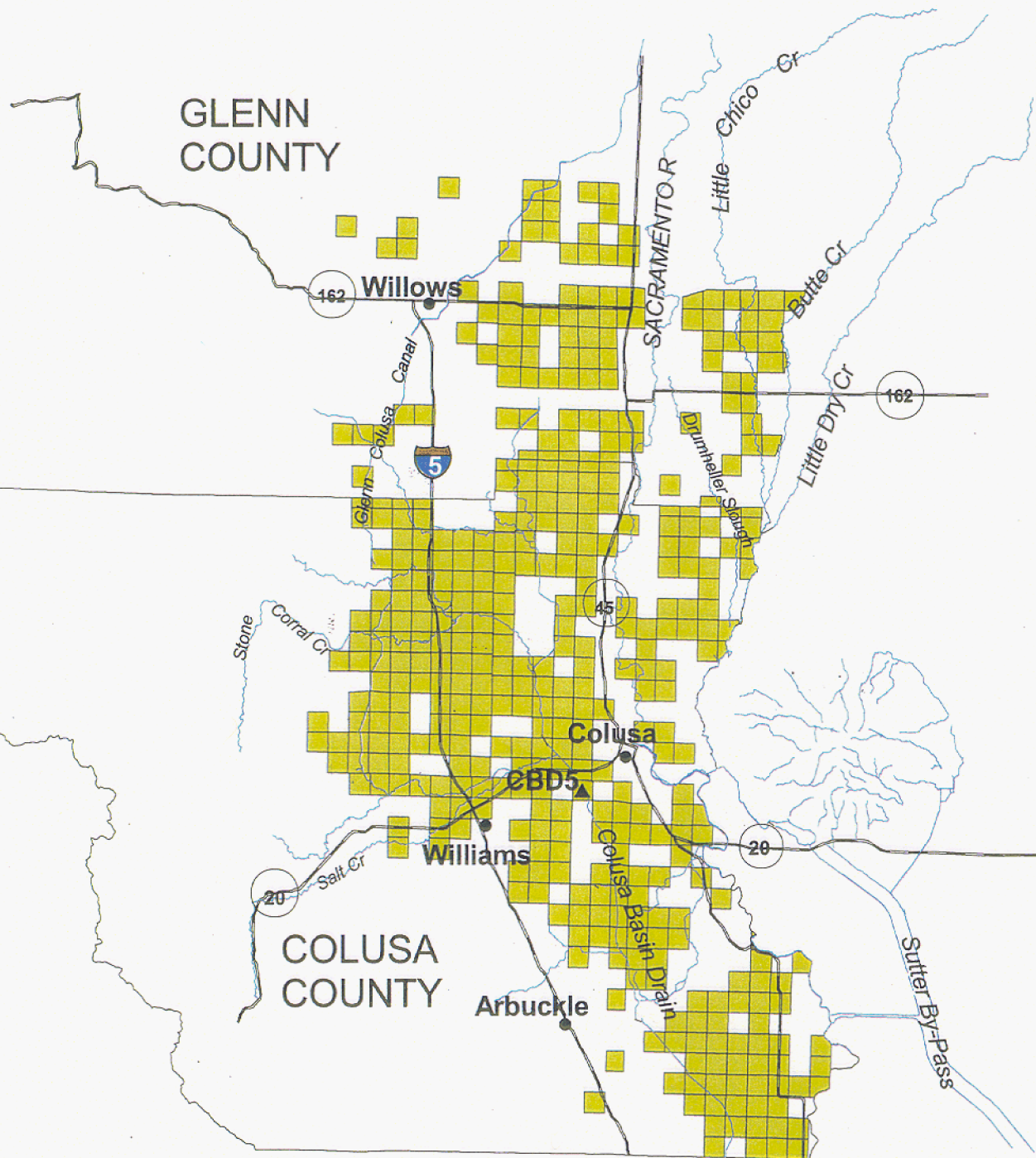





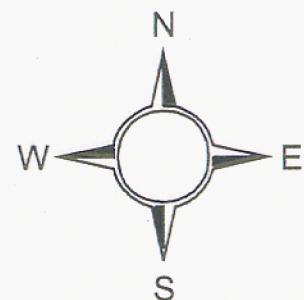


Figure 13. Thiobencarb use in Glenn and Colusa counties in 2000 based on one-square mile sections.

(Preliminary data reported by County Agricultural Commissioners. Subject to revision.)



-  Major Waterways
-  Major Roads
-  Thiobencarb Applications 2000
-  Towns and Cities
-  County Boundary



When comparing use of formulations of Abolish[®] and Bolero[®] it becomes clear Bolero[®] is the formulation rice growers prefer to use (table 4). Although, both formulations of thiobencarb have very narrow windows of application and can cause phytotoxicity, Abolish[®] can be even less efficacious than Bolero[®] when cool weather occurs during the application period. Additionally, growers report that they have experienced more phytotoxicity with Abolish[®] and its use requires that water be drained from fields when it is applied post-plant. Bolero[®] is more stable and easier to use of the two formulations. Rice growers are also relying more on thiobencarb in general, as weed resistance to molinate has increased.

Herbicide Alternatives

Thiobencarb is one of the few rice herbicides conventional rice growers currently have to combat weeds it helps control. New herbicides that are currently being considered for registration for use on rice offer other alternatives that could decrease the reliance on thiobencarb (table 5). However, none of these new herbicides offers a solution for controlling watergrass that has developed resistance to thiobencarb when used alone. Herbicide resistance is now known to exist where weed biotypes develop resistance to the mode of action of herbicides. Therefore, a weed can have resistance to new herbicides it has never been exposed to, if the new herbicide shares the same mode of action as the herbicide the weed is already resistant to. University researchers are currently working on a map that will document known fields where thiobencarb resistant weed biotypes are located in the Sacramento Valley. It is not currently known the extent of geographic area affected with thiobencarb resistance. Weed specialists now recommend rotation of herbicide combinations, to help avert and delay the development of resistance to rice herbicides.

Rice growers now have the example of Londax[®] (bensulfuron) to remind them resistance can occur when they rely on a certain herbicide, or combination of herbicides exclusively, successive seasons in a row. The result of this strategy can eventually decrease or eliminate the usefulness of that herbicide as a tool. Weed resistance has developed to propanil, another rice herbicide, in foreign rice growing countries and in the southern United States. Propanil is recommended as a tank mix with other rice herbicides. Researchers contend that there probably would be weed resistance to propanil in rice growing areas of California had it not been for a suspension of its use in the late 1960's and subsequent use restrictions that resulted, after phytotoxicity occurred to non-target agricultural crops such as prunes.

Weed resistance has also been identified with fenoxaprop, molinate, and bensulfuron in the Sacramento Valley. Clincher[®] (cyhalofop-butyl), a new product likely to be registered on rice controls sprangletop. Regiment[®] (byspyribac sodium), also a new herbicide likely to be registered, when used in a tank mix with thiobencarb can act synergistically to help control resistant watergrass. Both herbicides are not effective against thiobencarb resistant watergrass when used alone. These herbicides are recommended with tank mixes of propanil as well.

Table 5. Current and proposed herbicides for use on rice as of 2000

Product	Active Ingredient	Chemical Class	Mode of Action	Application Growth Stage	Target Weed Species							
					Watergrass	Springletop	Smallflower Umbrellaplant	Ricefield Bulrush	California Arrowhead	Redstem	Waterplantain	
Current Herbicides												
Abolish® 8EC	thiobencarb	thiocarbamate	fatty acid (VLCFA)	0-2 rice leaf	✓	✓	✓					
Bolero® 10G	thiobencarb	thiocarbamate	fatty acid (VLCFA)	1.5-3 rice leaf	✓	✓	✓					
Ordram® 15GM/8EC	molinate	thiocarbamate	fatty acid (VLCFA)	0-5 rice leaf	✓							
SuperWham® SC	propanil	amide	photostem inhibitor	3 rice leaf-mid tiller	✓		✓	✓	✓	✓	✓	
Stam® EDF	propanil	amide	photostem inhibitor	3 rice leaf-mid tiller	✓		✓					
Whip® 1EC	fenoxaprop	aryloxyphenoxy-propionate	ACCase inhibitor	5 rice leaf-mid tiller	✓	✓						
Londax® 60DF	bensulfuron	sulfonylureas	ALS inhibitor	0-5 rice leaf	✓		✓	✓	✓	✓	✓	
Grandstand® CA	triclopyr	pyridine carboxylic acid	synthetic auxin	5 rice leaf-mid tiller				✓		✓		
Shark® 40DF	carfentrazone	triazolinones	oxidase inhibitor	2 rice leaf-mid tiller			✓	✓	✓	✓		
Proposed Herbicides												
Clincher®	cyhalofop-butyl	aryloxyphenoxy-propionate	ACCase inhibitor	4 rice leaf-mid tiller	✓	✓						
Regiment®	bispyribac-sodium	pyrimidinyl-thiobenzoates	ALS inhibitor	5 rice leaf-mid tiller	✓			✓				
Sempre®	halosulfuron		ALS inhibitor				✓	✓	✓	✓		
Liberty®	glufosinate	phosphinic acid	glutamine synthase inhibitor	4 rice leaf-mid tiller	✓	✓	✓	✓	✓	✓		
Roundup®	glyphosate	glycine	EPSP synthase inhibitor									
Command®	clomazone	isoxazolidinones	carotenoid biosynthesis inhibitor	0.5 rice leaf-mid tiller	✓	✓						

Research conducted at University of California at Davis indicates that in order to avert resistance to these new compounds rice growers will need vigilance in alternating herbicide combinations and not relying on single strategies to control weeds. It has been suggested that pesticide labels could be useful in warning growers about resistance. Australia requires pesticide rotation as a condition of use for rice pesticides that are likely to cause resistance problems. Research continues regarding cross and multiple resistance which could make further herbicide rotation strategies even more difficult. Researchers have suggested an integrated long-term approach that directs selection pressure away from herbicides is needed (Powles and Mathews, 1992). Cultural weed methods in commercial rice production are limited. Researchers continue to work on developing competitive cultivars (Fischer et al. 1997) and submergence-tolerant varieties allowing increased water depth for weed suppression. It is also vital that measures be adhered to in order to prevent weed seed dispersal. In any event, weed resistance to herbicides will be a paramount issue in commercial rice production and rice weed management in California.

Conclusion

Increases have occurred in thiobencarb use for weed control in the principle commercial rice growing area of Colusa and Glenn counties. Increase in use of thiobencarb for watergrass and sprangletop control is strongly influenced by the following:

- Increases in total planted rice acreage.
- Increase in weed pressure and geographical spread of rice weeds, especially of sprangletop.
- A lack of alternative herbicides available to commercial rice growers for watergrass and sprangletop control.
- Development of resistant weed species requiring more frequent applications and higher use rates for effective control.
- Multiple and cross resistance to herbicides.
- Weed resistance to molinate with growers shifting to thiobencarb.

Increased thiobencarb detections in agricultural drains are influenced by the following conditions:

- Increase in use of thiobencarb.
- Drift during herbicide application.
- Seepage from rice fields with permeable levees following application and prior to adequate holding periods lapsing.

- Cool, wet weather that does not favor thiobencarb degradation following application.

DPR devotes many resources to stay informed of the overall conditions of rice production in California as part of the Rice Pesticide Program. All matters pertaining to pesticide use in rice production are closely reviewed. In comparison to other agricultural commodities grown in California a high level of regulation has been developed to address environmental concerns.

CAC staff expends many resources as well, prior to and during the growing season to ensure growers are complying with current restrictions. Cooperatively, the California Rice Commission, California Rice Research Board, California Rice Experiment Station, University of California Agriculture Extension and researchers, CACs, DPR, rice growers, and pesticide registrants provide on-going evaluation and efforts toward ensuring levels of rice pesticides are minimized in adjacent waterways. Water quality performance goals are the environmental target used as an on-going indicator of the success of these efforts. In the Colusa Basin Drain concentrations of thiobencarb in the early 1980's reached 60 ppb (Harrington and Lew, 1989). An indication of success of the rice pesticide program is the overall dramatic decline of concentrations of thiobencarb and other restricted rice pesticides in agricultural drains and the Sacramento River since the early 1980's. Fish kill incidents related to rice pesticides have not been reported to DPR, since that time.

Currently, United States Environmental Protection Agency's (USEPA) Office of Pesticide Programs (OPP) is developing improved product labeling to inform pesticide applicators of requirements to control off-target spray drift. OPP plans to publish these requirements and an implementation plan in a draft notice (PR Notice). In addition the Spray Drift Task Force, a consortium of 38 agricultural pesticide registrants, working under a cooperative research and development agreement with the USEPA and United States Department of Agriculture (USDA), had developed a model for predicting the off-field deposition of agricultural sprays.

In early 2001, DPR will put for the to stakeholders the first phase of a long-range plan for minimizing pesticide drift that involves revision of the current "drift control" regulations and the adoption of drift minimization requirements. Additional regulatory changes, the development of best management practices, and outreach activities are components of DPR's plan.

DPR is evaluating results of the 2000 Seepage Study to determine if further action is needed. The introduction of new reduced risk herbicides such as Clincher[®] and Regiment[®] will likely reduce the amount of thiobencarb being used, and are much less toxic and persistent than thiobencarb. Current water holding times are considered adequate for degradation of rice pesticides currently managed in this manner and for rice grower acceptance. Longer holding periods could result in poor growing conditions and crop loss. University researchers are actively involved in educating rice growers of the importance of cultural practices that encourage establishing strong rice stands to out

compete weeds; deep water in early rice establishment to suppress weeds; and alternating herbicide combinations to avert weed resistance. DPR will look toward these changes to have an impact on further reducing thiobencarb concentrations in waterways adjacent to rice fields.

APPENDIX 1



MEMORANDUM

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD CENTRAL VALLEY REGION

3443 Routier Road, Suite A, Sacramento, CA 95827-3003
(916) 255-3000 • CALNET 8-494-3000 • FAX (916) 255-3015

Cal/EPA



Pete Wilson, Governor

TO: James W. Wells, Director
Department of Pesticide Regulation
1020 N Street, Room 100

FROM: Gary M. Carlton
Executive Officer

DATE: 24 February 1998

SIGNATURE: 

SUBJECT: *Rice Pesticides Program*

Thank you for the annual report on your Department's Rice Pesticides Program.

As requested in your transmittal memo, the Board conducted a review of this report and a triennial review of the management practices your Department proposes to meet the Water Quality Control Plan's performance goals for carbofuran, malathion, methyl parathion, molinate, and thiobencarb. The Board adopted Resolution No. 98-024 (enclosed) approving the management practices for the 1998 through 2000 rice seasons.

The resolution also addresses four aspects of the rice pesticides program: seepage, aerial drift, trends in thiobencarb concentrations, and the new salinity provisions. The Board had concerns with each and I would like to summarize those concerns.

Seepage and aerial drift were identified in your report as the most significant sources of rice pesticides in surface water. The resolution clearly states that discharge of seepage water during the water holding times specified in the Department of Pesticide Regulation (DPR) control program is not an approved practice. This portion of the resolution should support the ongoing effort to encourage growers to voluntarily take steps to end seepage discharges. With respect to aerial drift, your report indicates that a regulatory program is under development that will benefit the rice pesticide control effort in the future. The resolution requests additional information regarding the specific steps that are being taken and the dates by which these measures will be implemented.

Thiobencarb concentrations in the Colusa Basin Drain have trended upward in recent years and in 1997 were several times higher than the Board's performance goal. The resolution requests DPR to evaluate steps that can be used to reduce this trend and report to the Board on its findings. This would be an appropriate subject for evaluation by the Rice Pesticide Working Group and the results could be included in the next annual report to the Board.

It is difficult to predict the impact of the new provision that allows emergency releases from fields impacted by salinity. Because of this, the resolution directs staff to bring this provision back to the Board if it appears that this change in the program results in significant impacts to water quality. We will work closely with your staff if it becomes necessary to bring this issue to the Board in the future.



The sustained efforts of your Department and the Agricultural Commissioners in conducting the Rice Pesticides Program are fully recognized and appreciated by the Board. We look forward to working with you and your staff on this and other programs and would like to acknowledge the assistance we received from John Sanders, Nan Gorder, and Marshall Lee of your staff during our review of the proposed management practices.

If you have any questions regarding the Board's Resolution, please call me at 255-3039 or your staff may call Rudy Schnagl at 255-3101.

Enclosure

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

RESOLUTION NO. 98-024

APPROVAL OF MANAGEMENT PRACTICES
REQUIRED BY THE DEPARTMENT OF PESTICIDE REGULATION'S
RICE PESTICIDE PROGRAM
FROM 1998 THROUGH 2000

WHEREAS, the California Regional Water Quality Control Board, Central Valley Region, (hereafter Board) adopted the third edition of the Water Quality Control Plan (hereafter Basin Plan) for the Sacramento and San Joaquin River Basins; and

WHEREAS, the State Water Resources Control Board approved the Basin Plan on 16 February 1995; and

WHEREAS, the Office of Administrative Law approved the Basin Plan on 9 May 1995; and

WHEREAS, the Basin Plan sets performance goals for the pesticides carbofuran, malathion, methyl parathion, molinate and thiobencarb and prohibits the discharge of irrigation return flows containing these materials unless the discharger is following management practices that the Board expects will result in compliance with performance goals; and

WHEREAS, the performance goals for carbofuran ($0.4 \mu\text{g/l}$), malathion ($0.1 \mu\text{g/l}$), methyl parathion ($0.13 \mu\text{g/l}$), molinate ($10 \mu\text{g/l}$), and thiobencarb ($1.5 \mu\text{g/l}$) will apply until the Basin Plan is amended; and

WHEREAS, the performance goals apply to all waters designated as freshwater habitat; and

WHEREAS, the Department of Pesticide Regulation (DPR) has a Rice Pesticide Program to reduce the off-target movement of pesticides applied to rice fields; and

WHEREAS, in a 23 December 1997 document titled "*Information on Rice Pesticides Submitted to the Central Valley Regional Water Quality Control Board*", DPR proposed a list of management practices that will control the discharge of carbofuran, malathion, methyl parathion, molinate, and thiobencarb from rice fields; and

WHEREAS, the DPR report indicates that aerial drift and seepage beyond the field perimeter appear to be the most significant sources of rice pesticides in surface water; and

WHEREAS, the information provided by DPR indicates that there is a trend toward increasing use of thiobencarb and that this has resulted in higher peak concentrations of this chemical in the Colusa Basin Drain; and

WHEREAS, the DPR program contains new provisions that allow emergency releases from fields impacted by salinity; and

WHEREAS, the Rice Pesticide Program has developed to a point where annual review by the Board is not needed; and

RESOLUTION NO. 98-024
APPROVAL OF MANAGEMENT PRACTICES
REQUIRED BY THE DEPARTMENT OF PESTICIDE REGULATION'S
RICE PESTICIDE PROGRAM
FROM 1998 THROUGH 2000

WHEREAS, the Board may review the Rice Pesticide Program at any time new information makes such a review necessary; and

WHEREAS, DPR acted as lead agency under the California Environmental Quality Act (CEQA) by developing the rice pesticide control effort pursuant to its certified program; and

WHEREAS, DPR consulted with the Board during preparation of the Rice Pesticide Program; and

WHEREAS, the Rice Pesticide Program concludes that there will be no adverse impacts to the environment, and after reviewing how the control program will be conducted in the period of 1998 through 2000, the Board agrees that there will be no significant impact on water quality; and

WHEREAS, the Board, in a public meeting, heard and considered all comments pertaining to proposed recommendations for the control of discharges containing the five pesticides; Therefore be it

RESOLVED, that the Board approves the management practices required by the DPR Rice Pesticide Program as appropriate for the discharge of rice field irrigation return flows containing carbofuran, malathion, methyl parathion, molinate, and thiobencarb during the years 1998, 1999, and 2000; and be it further

RESOLVED, that the discharge of seepage from rice fields to surface waters during the pesticide holding periods described in the DPR program is not an approved management practice if such seepage contains carbofuran, malathion, methyl parathion, molinate, or thiobencarb; and be it further

RESOLVED, that DPR is requested to provide the Regional Board with additional information on the specific steps that are being taken to further reduce aerial drift of pesticides and the dates by which any new measures will be implemented; and be it further

RESOLVED, that DPR is requested to evaluate steps that can be taken to reduce the trend of increasing discharges of thiobencarb and report to the Board on its findings; and be it further

RESOLVED, that staff is directed to schedule reconsideration of these management practices if water quality monitoring indicates that pesticide discharges resulting from the new salinity-related provisions of the DPR program are resulting in significant impacts to receiving waters.

I, GARY M. CARLTON, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Central Valley Region, on 23 January 1998.


GARY M. CARLTON, Executive Officer

APPENDIX 2

DRIFT CONTROL REQUIREMENTS FOR LIQUID THIOBENCARB APPLIED TO RICE – 1995

I. Aerial Applications

A. No aerial applications of liquid formulations of thiobencarb to rice shall be:

1. Discharged more than ten feet above the crop or target. Discharge shall be shut off whenever it is necessary to raise the equipment over obstacles such as trees or poles.
2. Applied when wind velocity is more than seven miles per hour.
3. Applied by aircraft except as follows:
 - a. The flow of liquid to aircraft nozzles shall be controlled by a positive shutoff system as follows:
 - i. Each individual nozzle shall be equipped with a check valve and the flow controlled by suckback device or a boom pressure release device; or
 - ii. Each individual nozzle shall be equipped with a positive action valve.
 - b. Aircraft nozzles shall not be equipped with any device or mechanism which would cause a sheet, cone, fan, or similar type dispersion of the discharged material except as otherwise provided.
 - c. Aircraft boom pressure shall not exceed 40 pounds per square inch.
 - d. Aircraft nozzles shall be equipped with orifices directed backward parallel to the horizontal axis of the aircraft in flight.
 - e. Fixed wing aircraft and helicopters operating in excess of 60 miles per hour shall be equipped with jet nozzles having an orifice of not less than 1/16 inch diameter.
 - f. Working boom length on fixed wing aircraft shall not exceed $\frac{3}{4}$ of the wing span; the working boom length of helicopters shall not exceed $\frac{6}{7}$ of the total rotor length or $\frac{3}{4}$ of the total rotor where the rotor length exceeds 40 feet.

APPENDIX 2

- g. Helicopters operating at 60 miles per hour or less shall be equipped with:
 - i. Nozzles having an orifice not less than 1/16 inch in diameter. A number 46 (or equivalent) or larger whirlplate may be used; or
 - ii. Fan nozzles with a fan angle number not larger than 80 degrees and a flow rate not less than one gallon per minute at 40 pounds per square inch pressure (or equivalent).
 - B. Special precautions should be taken to avoid off-site deposition of liquid formulations of pesticides when applications are made adjacent to agricultural drains.
- II. Ground Applications – Ground applications of liquid thiobencarb must be applied as per label instructions.

APPENDIX 3

THIOBENCARB WATER MANAGEMENT REQUIREMENTS- 1995

Revised April 7, 1995

- I. For rice fields treated with thiobencarb in the Sacramento Valley (north of the line defined by Roads E10 and 116 in Yolo County and the American River in Sacramento County), except those treated with Abolish® 8EC :
 - A. All water on treated fields must be retained on the treated fields for at least 30 days following application unless:
 1. The water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge 20 days following the last application of thiobencarb within the system.
 - a. If the system is under the control of one permittee, water may be discharged from the application site in a manner consistent with product labeling.
 - b. If the system includes drainage from more than one permittee, water may be discharged from the application site into the system seven days following application.
 2. The water is on fields within the bounds of areas that discharge negligible amounts of rice field drainage into perennial streams until fields are drained for harvest. Water from such fields must be held at least 19 days, unless the county agricultural commissioner evaluates such sites. If the commissioner verifies the hydrologic isolation of the fields, the water may be released seven days after application.
 - B. Fields not specified in I.A.1. and I.A.2. may resume discharging field water 31 days following application at a volume not to exceed two inches of water over a drain box weir. Unregulated discharges from these fields may then resume after seven days.

THIOBENCARB WATER MANAGEMENT REQUIREMENTS- 1995
Revised April 7, 1995

II. For rice fields treated with thiobencarb in the Southern Area (south of the line defined by Roads E10 and 116 in Yolo County and the American River in Sacramento County), except those treated with Abolish 8EC:

A. All water on treated fields must be retained on the treated fields for at least 19 days following application unless:

1. The water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge 20 days following the last application of thiobencarb within the system.
 - a. If the system is under the control of one permittee, water may be discharged from the application site in a manner consistent with product labeling.
 - b. If the system includes drainage from more than one permittee, water may be discharged from the application site into the system seven days following application.
2. The water is on fields within the bounds of areas that discharge negligible amounts of rice field drainage into perennial streams until fields are drained for harvest. Water from such fields may be released seven days after application if the county agricultural commissioner evaluates such sites and verifies the hydrologic isolation of the fields.

B. Fields not specified in II.A.1. and II.A.2. may resume discharging field water 20 days following application at a volume not to exceed two inches of water over a drain box weir. Unregulated discharges from these fields may then resume after seven days.

III. For all areas, fields treated with Abolish® 8EC:

A. All water on treated fields must be retained on the treated fields for at least 19 days following application unless:

1. The water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge 20 days following the last application within the system.

THIOBENCARB WATER MANAGEMENT REQUIREMENTS – 1995

revised April 7, 1995

- a. If the system is under the control of one permittee, water may be discharged from the application site in a manner consistent with product labeling.
 - b. If the system includes drainage from more than one permittee, water may be discharged from the application site into the system seven days following application.
 - 2. The water is on fields within the bounds of areas that discharge negligible amounts of rice field drainage into perennial streams until fields are drained for harvest. Water from such fields may be released seven days after application if the county agricultural commissioner evaluates such sites and verifies the hydrologic isolation of the fields.
- B. Fields not specified in III.A. may resume discharging field water 20 days following application at a volume not to exceed two inches of water over a drain box weir. Unregulated discharges from these fields may then resume after seven days.

**SUPPLEMENT TO WATER MANAGEMENT REQUIREMENTS
FOR THIOBENCARB –1998**

- IV. The county agricultural commissioner may authorize the emergency release of field water on the 20th day following the last thiobencarb application, following the review of a written application that demonstrates salinity levels are damaging to the crop.
- A. Applicants for such emergency releases must provide the following information:
1. All information indicated on the emergency release request form (Attachment A), including a description of the severity and extent of salinity damage.
 2. Electrical conductivity (EC) measurements, expressed as deciSiemens per meter (dS/m) or microSiemens per centimeter (μ S/cm), from field water in each paddy suspected of having salinity problems. To most effectively demonstrate salinity problems, measurements should be taken wherever salinity problems are evident.
 3. The instrument (make and model) used to determine EC measurements. The instrument must have a sensitivity range that accommodates the full range of EC values in intake and paddy water (usually a range of 0-5.0 dS/m or 0-5,000 μ S/cm should be sufficient) and should have a resolution of not less than five percent. The instrument must be calibrated according to the manufacturer's instructions. The applicant must specify the method of temperature compensation (i.e., automatic, conversion table).
 4. Who made the EC measurements.
 5. The source of irrigation water (e.g. district supply canal, drainage canal, well, etc.).
- B. An emergency release may be granted only if all of the following conditions are satisfied:
1. All required information is provided.
 2. Water management requirements for rice pesticides other than thiobencarb are satisfied.
 3. EC of paddy water exceeds 2.0 dS/m or 2,000 μ S/cm.
 4. The County Agricultural Commissioner or his or her staff inspects the site.

Appendix 3b

- C. Water may be released from paddies where EC measurements exceed 2.0 dS/m or 2,000 $\mu\text{S}/\text{cm}$ and from paddies down gradient from such paddies within the same field. Water shall only be released in an amount necessary to mitigate the salinity problem.
- D. Those issued an emergency release must submit to the county agricultural commissioner a report (Attachment B) indicating the time and duration of the emergency release and data that can be used to calculate the total amount of water released during the emergency release.

APPENDIX 4



Paul E. Helliker
Director

Department of Pesticide Regulation



Gray Davis
Governor

Winston H. Hickox
Secretary, California
Environmental
Protection Agency

MEMORANDUM

TO: Bob Rollins
Ag. Program Supervisor III

FROM: Kevin Kelley
Associate Environmental Research Scientist
(916) 324-4187

DATE: December 7, 2000

SUBJECT: Results of Thiobencarb Monitoring at Seepage Sites in Colusa and Glenn Counties

SCOPE OF THIS MEMORANDUM

The purpose of this memorandum is to provide results of water sampling conducted in the rice growing regions of Colusa and Glenn Counties, by the Department of Pesticide Regulation. This study was a preliminary monitoring effort to discern the potential for the rice herbicide thiobencarb to migrate from treated rice fields through levee walls into adjacent ditches. The study was expanded to include the herbicide molinate because; 1) chemical analysis procedures are identical to those for thiobencarb, and 2) molinate was detected in the first sample collected. Data included here are from water sampling efforts conducted weekly over the 10 week period from May 2 through July 4, 2000. Data consists of the chemical analysis of water samples taken from rice fields and their adjacent ditches, and environmental parameters collected at time of sampling.

BACKGROUND

The Department of Pesticide Regulation (DPR) implemented the Rice Pesticide Program in 1983 to reduce discharges of the rice herbicides molinate (Ordram®) and thiobencarb (Bolero® and Abolish®) into surface waterways. In 1990, the objectives of these control efforts were expanded, following the adoption of amendments to the Central Valley Regional Water Quality Control Board's (CVRWQCB) Water Quality Control Plan (Basin Plan). This plan established performance goals for molinate and thiobencarb beginning in 1990. These performance goals are 1.5 ppb for molinate and 1.5 ppb for thiobencarb (regardless of formulation).



One aspect of the Basin Plan was the establishment of on-field water holding periods, whereby pesticide-containing water is held on the rice-field for a prescribed period following pesticide application. The benefit of water holding periods is to afford rice pesticides the necessary time to degrade *in situ*, to concentrations that are minimally toxic to aquatic organisms, prior to release from the rice field. The water holding period for molinate is 28 days, and 19 days and 30 days for Abolish® and Bolero®, respectively. (Abolish® is a liquid formulation of thiobencarb and Bolero® is a granular formulation.) After the Basin Plan was implemented, concentrations of thiobencarb and molinate in surface waterways were significantly reduced.

Since 1997, peak concentrations of thiobencarb and molinate in the Colusa Basin Drain at Station 5 (CBD5) have exceeded the established performance goals. Concentrations in CBD5 exceeding the performance goals occur for a two week period, generally peaking prior to the onset of legal water releases; releases occurring after the required holding periods for thiobencarb have passed. While occasional emergency releases can occur before the expiration of the holding period based on heavy rain-fall or winds, thiobencarb concentration spikes have been hypothesized to be generally due to drift or seepage. The current concern is that thiobencarb levels in CBD5 are above the performance goals and are increasing in both duration and frequency.

Peak concentrations of thiobencarb and molinate occur before the onset of legal water release periods, and since illegal and emergency releases are not implicated as causative factors, another mechanism must be operating. The current supposition is that seepage waters containing pesticides and/or aerial drift of rice pesticides at application time are operative factors contributing to thiobencarb and molinate concentration peaks in CDB5.

Levees surrounding rice fields are designed to hold water on the rice paddy. Weir boxes in these levees, secured with plastic and soil, allow for controlled drainage from rice fields following appropriate holding periods. However, when the rice-field levees or borders are structurally compromised, water may move laterally through them. This water, referred to as seepage water, may contain pesticides which then enter agricultural drains before adequate time for degradation has passed. This water may eventually flow from the agricultural drains into the Sacramento River. Although, DPR has a voluntary seepage water management program currently in place, the CVRWQCB does not view this program as an approved management practice, if those seepage waters contain rice pesticides above the performance goals.

In 1995, DPR through the County Agricultural Commissioners (CACs) in Butte, Colusa, and Glenn Counties informed growers of the potential implications of seepage. A one-page handout entitled "Closed Water Management Systems" was prepared by DPR, the rice industry, the University of California (UC) Cooperative Extension, Davis, and the United States Department of Agriculture. In 1998, DPR and UC Cooperative Extension, Davis, jointly produced an additional publication entitled "Seepage Water Management, Voluntary Guidelines for Good Stewardship in Rice Production". Both documents supply growers with detailed information for recognizing seepage and provide suggestions for management practices to prevent seepage.

DESCRIPTION OF PROBLEM.

The 1997 triennial report (covering Rice Pesticide program activities from 1995 through 1997) submitted to CVRWQCB, contained data which indicated that thiobencarb concentrations exceeding the performance goals occurred at CBD5 and other areas before required holding periods had lapsed and normal releases occurred. Since thiobencarb concentrations exceeding the performance goal occur before the expiration of the required holding periods, and since premature release of rice-field waters were not implicated, thiobencarb-laden rice-field waters seeping through and under levees and drift, during thiobencarb application, were postulated as contributing factors. On January 23, 1998, the CVRWQCB resolved to request DPR to "evaluate steps that can be taken to reduce the trend of increasing discharges of thiobencarb . . .".

SAMPLING AND ANALYTICAL METHODS:

The objective of this monitoring was to assess the potential for the rice herbicide thiobencarb to move through rice levees. In 2000, DPR monitored water at sites in Colusa and Glenn Counties where seepage of rice-field waters had previously been identified. DPR and CAC staff selected one site in Glenn County and one site in Colusa County. Both sampling sites were located within 5 miles of Princeton, California (Figure 1). Sample collection sites were selected using the following three factors: 1) Seepage through levee walls was known to occur at the sample site, 2) Both the field and the adjacent ditch contained water at the onset of sampling; and 3) Ditch was not directly fed by headwater nor tailwater from nearby rice fields.

Samples were collected from sites located in Colusa and Glenn Counties. Over the course of ten weeks (May 2 through July 4, 2000), grab samples (and back-ups) were collected in 1-Liter amber bottles, stored on ice and transported to the CDFA's Chemistry Laboratory for analysis. Quality control procedures were implemented on weeks 3, 6, and 9, when 5 liters of water was collected and split into primary, secondary, and backup samples. Primary samples were analyzed by CDFA, secondary samples analyzed by Valent Laboratories (Dublin, CA). Backup samples were stored for analysis in cases where confirmation of analytical results might have been required.

Grab samples were collected in 1-Liter amber bottles. Ditch samples were collected by hand or by grab pole; field samples were collected by grab pole. Quality control samples were collected via a one-quart mason jar attached to the grab pole. Approximately, five quarts of water were collected at each site, pooled in a 2.5 gallon glass jar, stored on ice, and transported to EM&PM's warehouse in West Sacramento for splitting. A Geotech® 10-port splitter was used to divide samples. Samples were refrigerated to 5 °C following collection and storage prior to shipping to the laboratories.

Water quality parameters collected *in situ* included temperature, dissolved oxygen (DO), pH, and electrical conductivity (EC). A Dual Technologies pH, temperature meter was used to collect pH samples. A YSI Model 85 oxygen/conductivity/salinity/temperature meter, was used to collect electrical conductivity, temperature and dissolved oxygen content of field and ditch waters.

RESULTS AND DISCUSSION

Thiobencarb Concentrations in Rice field and Ditch Water Samples

Primary samples were analyzed for thiobencarb by the CDFA Chemistry Lab, and split samples were analyzed by Valent Corp. Molinate is also identified by the same method, and was detected in the first sample. Thereafter, samples analyzed by CDFA for thiobencarb were also analyzed for molinate. Concentrations of molinate and thiobencarb are listed in Table 1. Samples were collected for all sampling dates in Colusa County, however, no samples were collected on June 13, and June 20, in Glenn County, as the field had been drained by June 13, and remained dry on

June 20. Between June 20, and June 27, the field was re-flooded and water again appeared in the ditch. Samples were again collected on the June 27, and July 4, in Glenn County.

Colusa County

Thiobencarb was detected in six of ten water samples collected from the rice-field. Concentrations decreased from a high of 607 ppb (week 3) to 0.98 ppb (week 8) and thiobencarb was not detected in samples collected weeks 9 and 10. Thiobencarb concentrations were above the performance goal in all samples collected during weeks 3 through 7 (the five weeks following application). Sampling on week three (May 16) was conducted soon after the application of thiobencarb.

Thiobencarb was detected in four of ten water samples collected from the ditch adjacent to the rice-field sampling site. Thiobencarb residues were above the performance goal (1.5 ppb) in three of the 4 samples. Concentrations of thiobencarb in ditch samples were greater in the last half of sampling (weeks 6 and 7) than in the beginning (weeks 3 and 4). Concentrations of thiobencarb in the ditch, exceeded concentrations in the rice-field on weeks 6 and 7.

Glenn County

Thiobencarb was detected in five of eight water samples collected from the rice-field. Samples were not collected on weeks 7 and 8 (June 13 and June 20) as the field had been drained. Concentrations decreased from a high of 223 ppb (week 3) to 1.1 ppb (week 10) and was not detected in samples collected weeks 1, 2, and 4. Application information for thiobencarb in this area was not available. Thiobencarb concentrations were above the performance goal in samples collected for weeks 3, 5, 6, & 9.

Six of ten water samples (weeks 3, 4, 5, 6, 9, and 10) collected from the ditch sampling site contained thiobencarb residues, at or above the performance goal (1.5 ppb). Again samples were not collected on weeks 7 and 8 because the field had been drain and seepage ceased. Samples were collected on weeks 9 and 10 as the field was re-flooded and seepage again occurred. Following initial detection, thiobencarb concentrations in the Glenn County ditch exceeded or equaled performance goal levels (1.5 ppb) in all samples collected.

Water Parameters

Water parameters were taken from the sample sites immediately following sample collection. Values for dissolved oxygen, electrical conductivity, temperature and pH are presented in Table 2 and graphed in Figure 2.

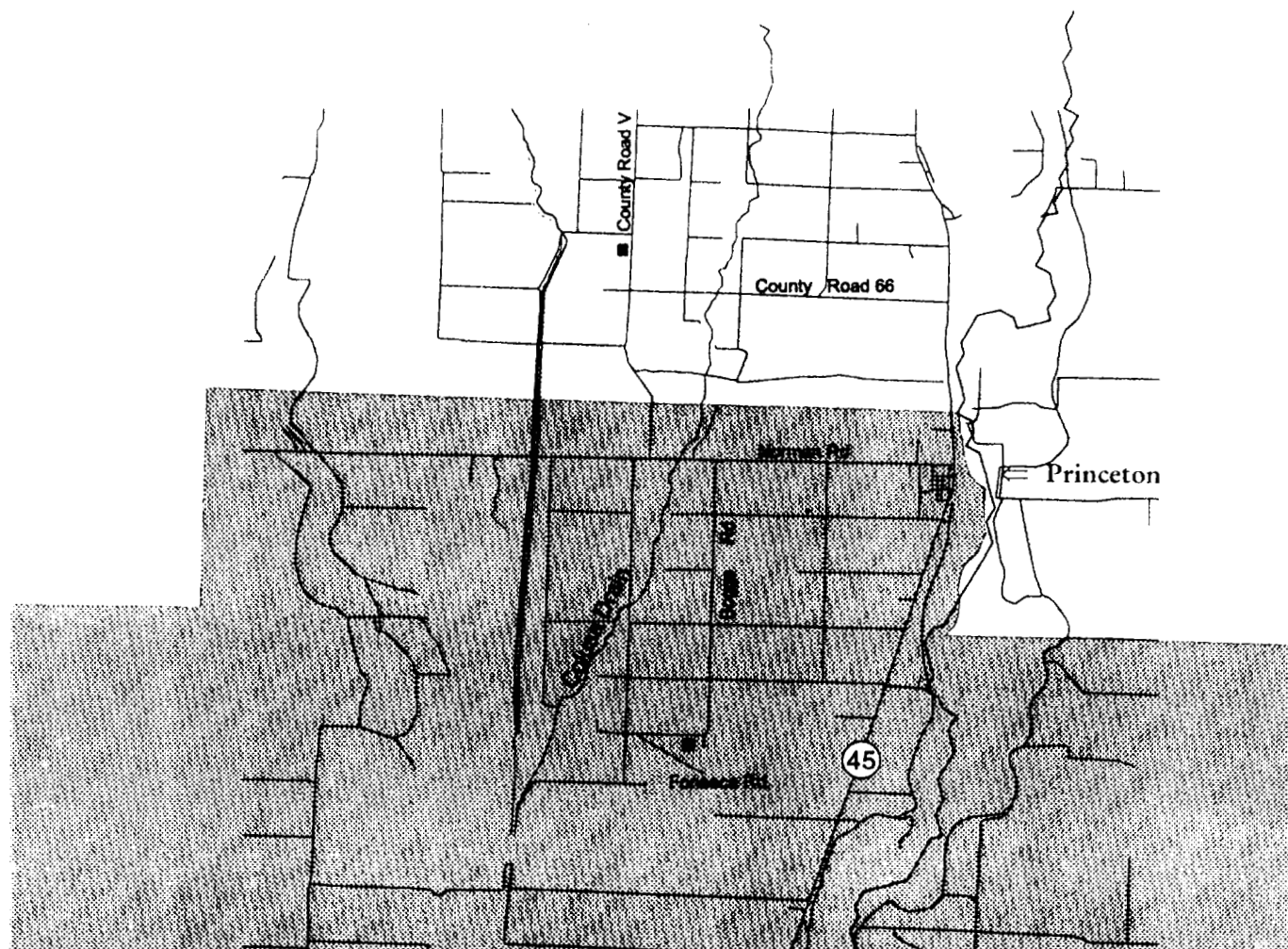
Thiobencarb Application

Thiobencarb applications to rice-fields near the Colusa County sampling site are presented in Figure 3. The sample collection site in Colusa county was located in Section 34 of Township 18N, Range 2W. Six applications of thiobencarb were made near the sample collection site, 2 in Section 34 (May 12, and 16), and 4 in Section 35 (May 4, 6, 24, and 27). The thiobencarb application to acreage in section 34 on May 16, coincides with the high thiobencarb concentrations detected in field waters later that same day. Data concerning thiobencarb applications to acreage in Glenn county is not currently available. Data concerning molinate applications are not currently available for either Glenn or Colusa Counties.

CONCLUSIONS

Based on the results of this survey, both molinate and thiobencarb were found in ditches adjacent to rice fields treated with these pesticides. Seepage was probably occurring as evidenced by the simultaneous presence of water in ditch and the adjacent field. The potential source(s) of thiobencarb and molinate in the ditches was either seepage or drift following application. Molinate and thiobencarb concentrations in rice-field ditches tended to be greater than the performance goals, but less than thiobencarb concentrations in adjacent field waters.

Figure 1: Site Location for Thiobencarb and Molinate Monitoring in Colusa and Glenn Counties



0 1 2 3 Miles

- Sample Sites
- Roads
- Water Bodies**
 - Sacramento River
 - Willow Creek
 - Colusa Drain
- Counties**
 - COLUSA
 - GLENN



Table 1. Seepage Monitoring Results in Colusa and Glenn Counties. (Concentrations Expressed in ug/Liter).

	Monitoring Site											
	Colusa Field			Colusa Ditch			Glenn Field			Glenn Ditch		
Sample Type	Molinate	Thiobencarb		Molinate	Thiobencarb		Molinate	Thiobencarb		Molinate	Thiobencarb	
	<u>Primary</u>	<u>Primary</u>	<u>QC</u>	<u>Primary</u>	<u>Primary</u>	<u>QC</u>	<u>Primary</u>	<u>Primary</u>	<u>QC</u>	<u>Primary</u>	<u>Primary</u>	<u>QC</u>
Reporting Limit (ug/L)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Date												
2-May	NA	ND	NA	NA	ND	NA	0.767	ND	NA	ND	ND	NA
9-May	NA	ND	NA	NA	ND	NA	NA	ND	NA	NA	ND	NA
16-May	338	607	460	48	1.8	2.0	1.3	223	173	0.55	78	67
23-May	265	182	NA	77	0.83	NA	18	ND	NA	2.7	27	NA
30-May	9.4	10.7	NA	18	ND	NA	2.1	66	NA	0.75	10	NA
6-Jun	2.5	1.6	1.6	25	4.4	0.5	1.8	15	14	0.7	2.8	3.4
13-Jun	2.7	1.8	NA	31	3.9	NA	NS	NS	NS	NS	NS	NS
20-Jun	1.6	0.98	NA	6	ND	NA	NS	NS	NS	NS	NS	NS
27-Jun	0.53	ND	ND	14	ND	ND	0.6	2.4	1.9	ND	3.6	2.9
4-Jul	ND	ND	NA	4.1	ND	NA	ND	1.1	NA	ND	1.5	NA

QC **Quality Control**
ND **Not Detected**

NS **Not Sampled**
NA **Not Analyzed**

Performance Goals 1.5 ug/L

Table 2: Values for Environmental Data Collected at Thiobencarb Monitoring Sites.

DATE	Dissolved Oxygen			
	Colusa County		Glenn County	
	Ditch	Field	Ditch	Field
2-May-00	2.17	11.60	5.03	8.61
9-May-00	2.45	10.40	5.98	9.70
16-May-00	2.65	9.23	5.02	6.50
23-May-00	0.53	5.32	2.60	5.70
30-May-00	2.00	10.15	--	6.50
6-Jun-00	1.68	5.41	6.41	3.04
13-Jun-00	1.51	3.92	--	--
20-Jun-00	1.76	2.98	--	--
27-Jun-00	1.50	5.50	5.10	3.70
4-Jul-00	2.06	6.40	0.06	3.60

DATE	pH			
	Colusa County		Glenn County	
	Ditch	Field	Ditch	Field
2-May-00	6.66	9.80	7.32	7.54
9-May-00	6.76	7.48	--	7.64
16-May-00	6.97	7.57	7.33	7.62
23-May-00	6.77	7.19	7.56	7.80
30-May-00	6.96	7.51	--	7.82
6-Jun-00	6.72	7.29	7.02	7.23
13-Jun-00	6.76	6.48	--	--
20-Jun-00	7.03	6.70	--	--
27-Jun-00	6.56	6.63	7.20	6.90
4-Jul-00	6.64	6.98	6.86	6.55

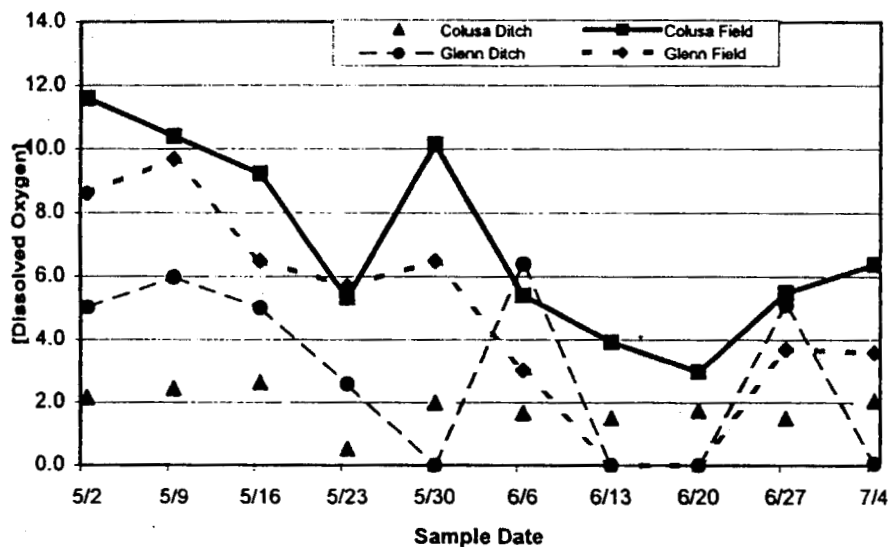
DATE	Conductivity			
	Colusa County		Glenn County	
	Ditch	Field	Ditch	Field
2-May-00	96.1	151.1	357.2	214.7
9-May-00	100.0	123.0	216.0	268.1
16-May-00	5.7	136.0	308.5	287.5
23-May-00	155.0	234.0	140.0	261.0
30-May-00	172.0	177.2	--	470.0
6-Jun-00	273.9	142.5	9.7	432.8
13-Jun-00	55.0	78.0	--	--
20-Jun-00	3.2	156.1	--	--
27-Jun-00	1.5	177.4	3.2	253.5
4-Jul-00	1.9	159.3	166.3	275.2

DATE	Temperature °C			
	Colusa County		Glenn County	
	Ditch	Field	Ditch	Field
2-May-00	22.0	26.8	30.1	25.3
9-May-00	16.6	17.0	18.9	20.3
16-May-00	14.7	12.7	14.8	14.0
23-May-00	23.0	24.3	23.8	23.7
30-May-00	18.0	18.3	--	20.1
6-Jun-00	19.8	20.8	23.2	22.5
13-Jun-00	22.2	21.4	--	--
20-Jun-00	25.4	22.5	--	--
27-Jun-00	24.5	23.4	27.0	25.9
4-Jul-00	20.1	20.0	22.2	21.6

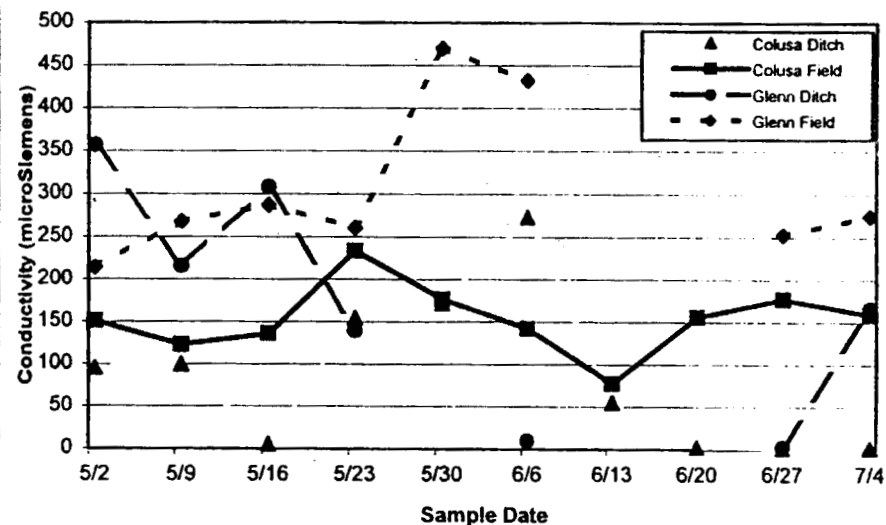
DATE	Time			
	Colusa County		Glenn County	
	Ditch	Field	Ditch	Field
2-May-00	12:30	12:45	13:30	13:45
9-May-00	9:00	9:15	10:15	11:00
16-May-00	8:50	9:15	9:45	10:00
23-May-00	8:45	8:55	9:40	9:30
30-May-00	9:00	9:25	10:15	10:30
6-Jun-00	9:00	9:15	9:45	10:00
13-Jun-00	9:10	9:25	10:00	10:00
20-Jun-00	9:15	9:30	10:00	10:00
27-Jun-00	8:45	9:00	9:15	9:30
4-Jul-00	9:15	9:30	10:15	10:30

Figure 2. Plot of Environmental Data Taken at Time of Sampling.

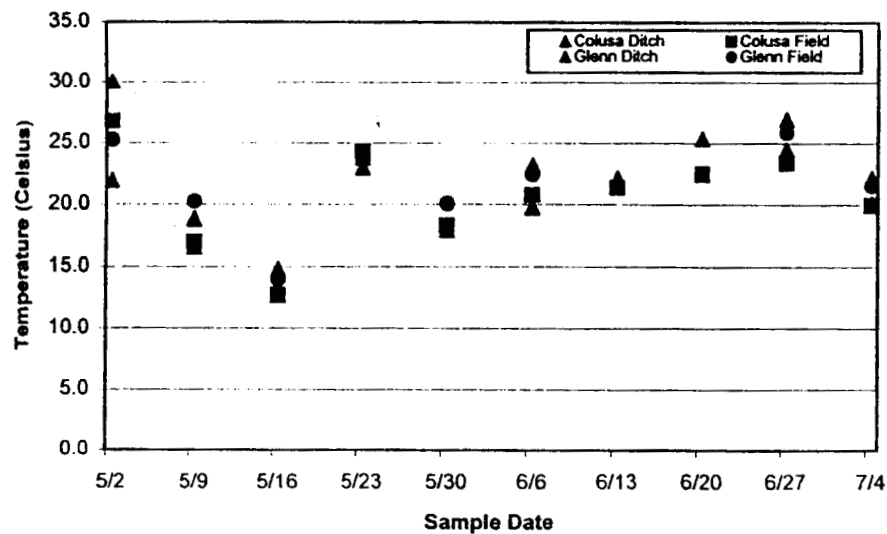
Dissolved Oxygen Content in Water from Fields and Ditches Sampled for Thiobencarb



Electrical Conductivity of Water from Fields and Ditches Sampled for Thiobencarb



Water Temperature in Fields and Ditches Sampled for Thiobencarb



pH of Waters from Fields and Ditches Sampled for Thiobencarb

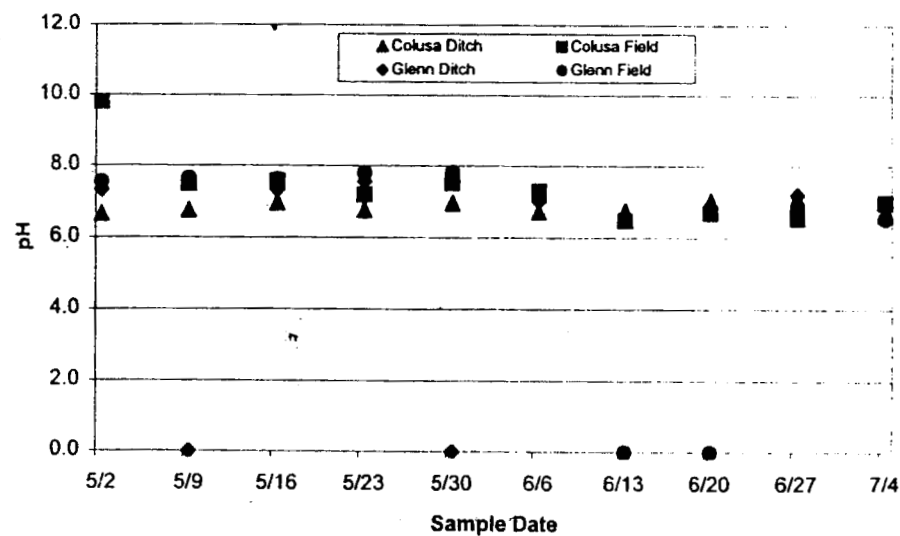
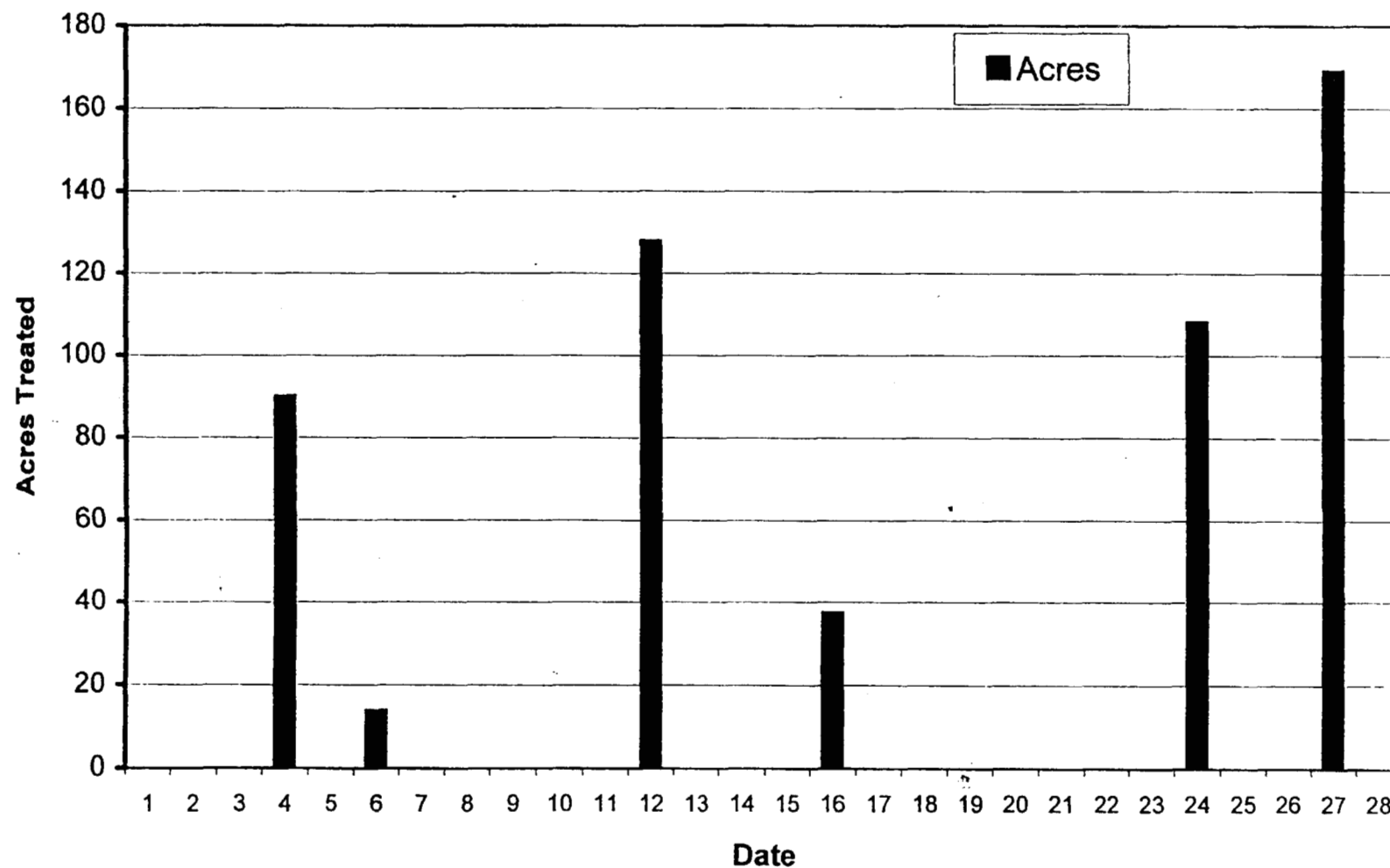


Figure 3. Thiobencarb Applications to Rice Fields Adjacent to Monitoring Sites in Colusa County, May 2000.



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